POWER

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Do You Need an Engineer?

POWER has been dealing with the engineers of the country for a third of a century. It knows them not only as a class, but out of its constituency many individuals have come to our especial notice through long association, intelligent interest evinced by correspondence with the editors, contributions to our columns and by especial achievement.

We have seen men grow from the time when their awakening interest led them to come to us with the questions which arose when they just began to look for the "why?" of things, until they are in charge of large installations and occupy the highest plane in their vocation.

We know men who are modestly following out a daily round in small positions whose attainments qualify them for better things.

We know good men who are temporarily out of employment.

We know mediocre men for those who do not care to pay for better.

If you are thinking of making a change, if your engineer has left or is going to leave it, it will be a pleasure for us to undertake to put you into communication with a suitable man, to tell you what we know about him and leave you to make your own arrangements.

That we may do this intelligently it is necessary that we should know the size and character of your plant; the degree of authority and responsibility with which the man is to be invested; the opportunity for advancement and for making a record; the salary or wages which you are willing to pay, the hours during which the plant is run, etc.

This may be given to us with the fullest confidence that it will not be divulged or misused in such a way as to cause you any annoyance.

Do You Want a Position?

POWER has recommended many men to situations and in few, if any, cases have they failed to make good. An increasing number of employers are coming to us for such recommendations and we like to be used in this way.

While we enjoy the acquaintance and are informed as to the capabilities and aspirations of many of our readers, we realize that there are very many equally entitled to consideration and whom we should be equally glad to help of whom we have no personal knowledge.

POWER will best serve its purpose when it is most useful to its readers and we shall be glad if we can make it more useful by helping them to better positions.

If you are out of a position, if you feel that you are capable of greater things than your present situation affords or promises, write and let us see if we can do anything for you. Tell us what your experience has been, what sorts and sizes of plants you have handled, whether you have been in responsible charge or simply standing watch. What sort of a record have you made? Where are you willing to go? What is the minimum salary you will consider? To whom can you refer for testimonials as to character and ability?

You can send us this information with the fullest confidence that it will not become known outside of our office. You need not worry for fear your present employer will learn that you are trying to improve your condition. Keep in touch with us, keep us in mind of you and keep your record with us complete so that when we receive an inquiry for a man of your type we shall find your name and the best argument you can present for your claim for consideration in our file.

A Coney Island Power Plant

By Warren O. Rogers

One of the few isolated power plants at Coney Island which has not been supplanted by the central station.

Two of the engines are 19 years old and one has been in service for 34 years, but electrical energy is delivered to the switchboard for less than 2 cents per kilowatt-hour.

Of the thousands of visitors to Coney Island during a season, but few realize that there is but one large isolated-power plant in operation on the island. This plant is at Feltman's, which is said to be the largest resort of its kind in the world, and provides for the wants of 25,000 people in one day in the restaurant alone; and as many as 36,000 frankfurters and rolls have been sold in a day during the past season.

This plant is in charge of James A. Westberg and the thousands of engineering friends who have visited this resort have doubtless wondered how the plant can be kept in operation when competition by the central station is so strong. In fact, most of the current supplied for illuminating and power purposes at Coney Island is taken from the central station. It is said upon good authority, however, that next season several of the plants which were discarded for central-station service will be put back into operation, and that in one or more instances new power plants will be constructed.

After the visitor has passed through the main entrance of Feltman's and down by the various gardens, if he will turn to the left through a passageway he will see the steam plant which illuminates this resort.

In the engine room there are two 16x16-inch Ames, and one 12x14-inch Armington-Sims engines. Both of the Ames engines have been in service 19 years and the small engine has been in service for 34 years. All are used every night during the open season. They are direct connected to a 100-kilowatt and a 30-kilowatt direct-current generator respectively. Generally 115 volts is carried on the switchboard, which is comprised of three Vermont marble panels upon which the switches, recording instruments, etc., are mounted. There are five distributing boards located at different points throughout the establishment so that the several gardens can be cut in or out as desired without notifying the engine room. The plant frequently runs with a load of 300 kilowatts, most of the current being used for illuminating purposes. A view of the engine room is shown in Fig. 1.

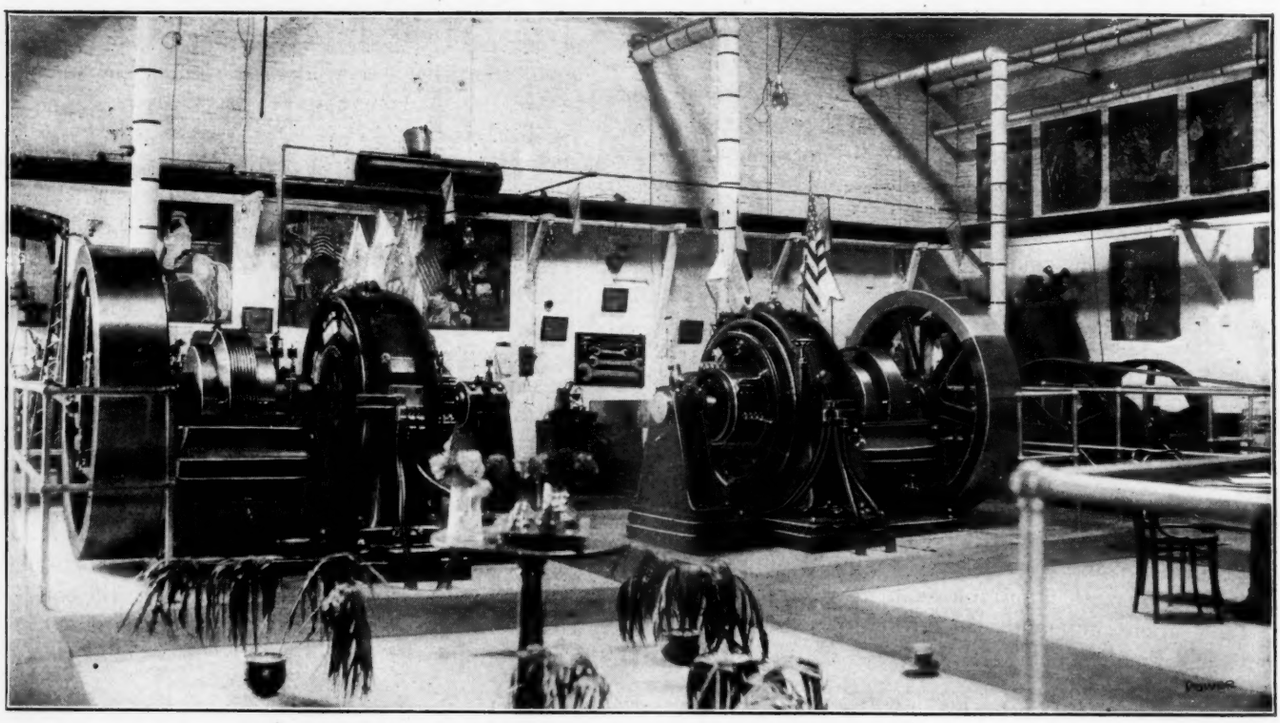


FIG. 1. PARTIAL VIEW OF THE ENGINE ROOM AT FELTMAN'S

Naturally, in such an establishment as this it is necessary that the fresh meats and other perishable provisions shall be kept at suitable temperatures; therefore various cold-storage rooms have been built convenient to the kitchens. A 30-ton brine Frick refrigerating machine is located in the engine room and supplies the refrigerant for the entire establishment. There is also one 15-ton machine, which was the original installation, but this unit is now held in reserve. They are shown in Fig. 2. The machines are connected with a triple-pipe cooling system and after the brine has passed through the 38 ice boxes it is used before returning to the cooler to freeze the ice in the ice cans.

There are two 6¾x6-inch brine pumps. In case one should give out, the other will take care of the brine and prevent the system freezing.

The construction of the buildings at Coney Island are of wood and other inflammable material and therefore fire protection independent of that supplied by the town is necessary. To provide for this, a 16 and 9 by 12-inch fire pump is kept under steam pressure both day and night during the season. There is also a 10 and 6 by 12-inch pump which can be used for fire protection, but it furnishes water for laundry, kitchen supply, etc., at other times. Water can be put on any part of the house in 39 seconds, so thoroughly are the employees drilled. There are 8000 feet of 2½-inch hose and 14 monitors on the roof, each capable of delivering 250 gallons of water per

minute. This enables the fire fighters to do excellent work, and in the case of a recent fire in a neighboring building, they had their hose playing on it some time before the arrival of the fire department upon the scene.

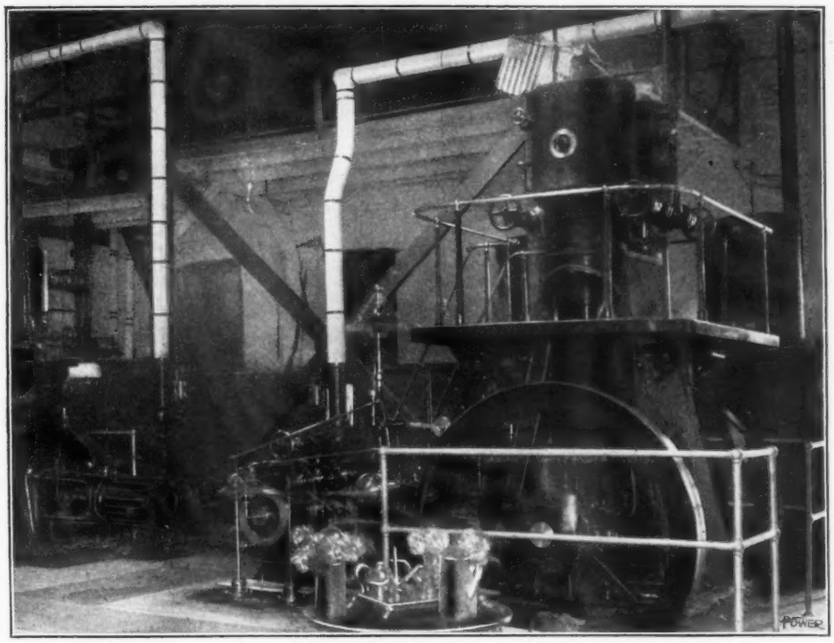


FIG. 2. NEW 30-TON AMMONIA COMPRESSOR

All cooking throughout the establishment is done by steam with the exception of roasting and broiling. There are seven kitchens to be supplied besides the department for steaming clams, lobsters, etc.

In the boiler room, Fig. 3, there are two 100-horsepower, two 80-horsepower and one 200-horsepower return-tubular boilers; there is also a 260-horsepower water-tube boiler. These boilers are hand fired and pea coal is used at a cost on delivery to the boiler room of $4.20 per ton. An average of 8½ tons of coal per day of 24 hours is burned. The cost of putting electrical energy on the switchboard is less than 2 cents per kilowatt-hour, which cost includes wages, supplies, repairs and depreciation of the plant.

Although the engines in this plant have been in service over 19 years, and one of them over 34 years, electrical energy is produced at a lower rate than it can be purchased from the central station, which not only speaks well for the ability of the chief engineer, but also emphasizes the fact that if an engineer has the capabilities he will have no trouble in producing current at a lower rate than it can be purchased from outside sources. The plant is kept in a very neat and clean condition, the machines look almost like new and the low cost of operation is due to the management of Chief Engineer Westberg. The plant is well worth looking over by any visitor who happens to be in the vicinity.

Passing of Another Veteran

BY JOHN S. LEESE

The Brownsfield mills, of Manchester, England, were built in 1820 and the motive power for the machinery was furnished by a single-cylinder condensing double-acting throttle-governed beam engine made by the then famous firm of engineers, Peel, Williams & Peel. Until a few months ago this old engine kept the wheels turning in the mills, and if excellence of material, sound construction and minimum wear are any criteria it would have done so for many years to come. One of the chief reasons for scrapping the engine and replacing it by electric motors was the discontinuance of woodworking machinery by one of the tenants in the mill, the chips formerly having been used as fuel under the boilers. Another reason was the small load factor due to the different working hours of the various tenants.

The bore and stroke of the engine were 38 inches and 7 feet 6 inches respectively, and the speed was 18 revolutions per minute. The length of the beam was 22 feet 6 inches and it was 3 feet deep in the center across the bearings. The hight of the cylinder casting was 9 feet from flange to flange and the valve chamber, in which worked an old type "D" slide valve, was cast integral with it. The cast-iron connecting rod was 21 feet long and the crank pin was 5 inches in diameter by 7½ inches long. This was keyed into the 8½-inch thick oval-shaped crank web, which, in turn, operated the cast-iron crank shaft which had a maximum machined diameter of 10 inches and a length of 8 feet. The shaft was only

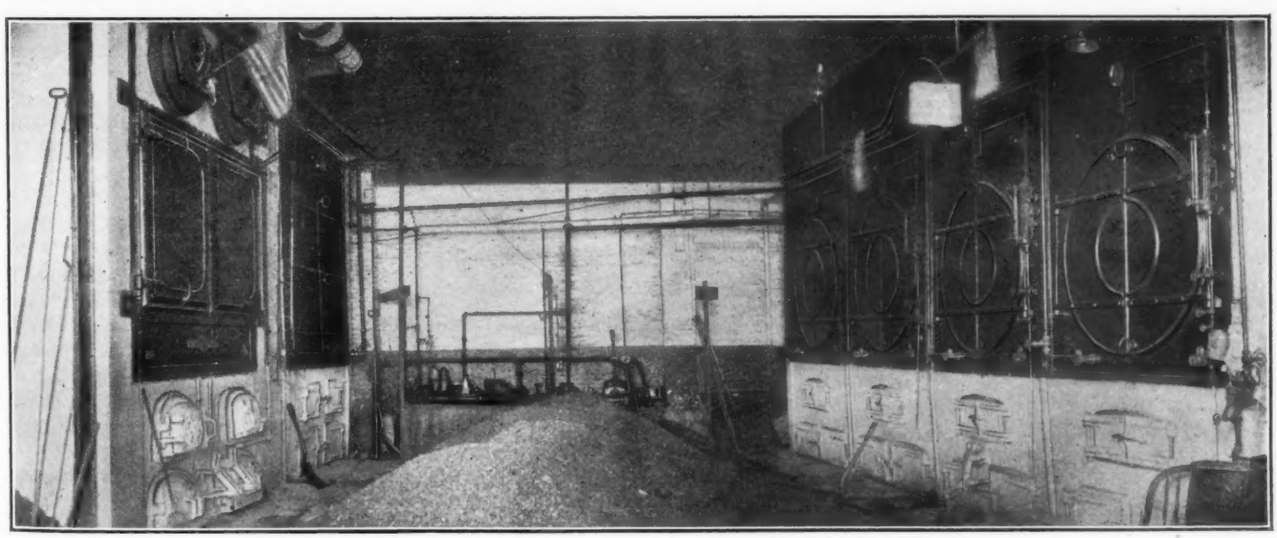


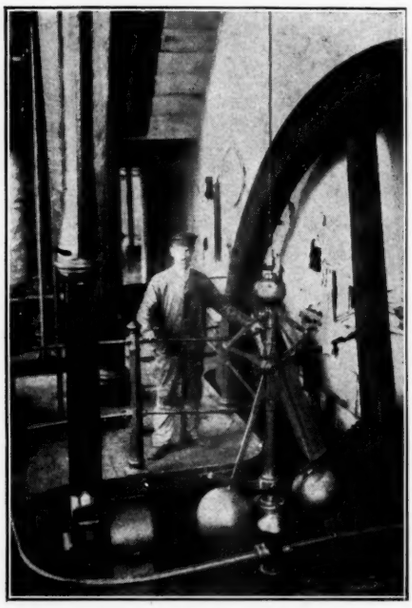
FIG. 3. BOILERS HAVING COMBINED CAPACITY OF 820 HORSEPOWER

machined at the journals and flywheel, eccentric and spur-wheel necks. The flywheel was 24 feet in diameter and weighed about 14 tons. It was segmentally built up of eight sections, the spokes being tapered from 4½x12 inches, rectangular section, at the boss end to 3¾x9½ inches at the rim end.

Keyed to the crank shaft, outside the flywheel and inside the outboard bearing, was a spur wheel driving a wheel on a second-motion shaft. On this second-motion shaft was mounted a bevel wheel meshing with another bevel wheel on an upright shaft; this, in turn, extended to the top of the mill, each of the seven stories deriving its power from line shafts driven by bevel gears off the vertical shaft. The diameter of the vertical shaft was reduced step by step as it ascended from floor to floor.

In the early sixties, one wing of the mills, which are L-shaped in plan, was gutted by fire and all the shafting in that portion was destroyed, but, up to the time of being discontinued, the whole of the original gearing and shafting in the old part of the mills was in operation, with the exception of the old jaw couplings in one of the weaving sheds which were replaced by muff couplings.

The valve of the old packed "D" slide type and the original hemp-packed piston, more recently fitted with a Lancaster spiral-spring type ring, were unchanged throughout the life of the engine. All bearings and journals were



PARTIAL VIEW OF ENGINE

plain unbushed iron to iron and were lubricated with ordinary heavy engine oil.

The engine was fed with steam at 60 pounds pressure by an 8-inch steam pipe from two 28x7-foot patent two-flue Galloway boilers which were installed in 1879. These boilers replaced the original wagon-type boilers which were installed with the engine in 1820.

A 27-inch vacuum was maintained to the last by the original jet condenser. The feed and condensing water were obtained from a branch of the Rochdale canal, which runs outside the mills. This branch gets all the dirt and scum from the main canal washed into it by the boats so that the builders suffered rather badly from foaming and scaling. The chimney was built into the middle of the circular staircase leading to the several stories of the mills and on the top of the stack was a ring-shaped tank or cistern which received the overflow from the boiler-feed pump. Pipes from this tank to the different stories of the building conveyed water for fire purposes and to the boilers in case of emergency or accident to the feed pump.

The photograph of the engine shows the old cross-arm type of governor with its vertical operating rod reaching overhead, the cast-iron connecting rod, the cylinder, part of the valve rods and one of the columns in the background. It will also be noticed that the crank pin is cottered to the web in the old style with the cotter pin right through both pin and web.

Value of Engine Room Inspection

By Hubert E. Collins

A thorough inspection of the entire plant by the engineer when going on watch will often avert serious trouble, besides fixing the responsibility should anything wrong be discovered. Several instances are cited to show the advisability of such a practice.

The "trouble man" who visits many plants finds in the majority of cases that if the operator in charge had used a system of inspection, he could have avoided trouble. Outside of steamship operation and large power houses, where discipline is enforced, there are hundreds of plants in charge of men who never had the proper training and who do not see the necessity of systematic inspection.

What better name than "scientific management in the engine room" could be applied to a system whereby the operator upon shutting down for the day looks over his engine and examines by sight and touch every part. He feels all the bearings to see if they are cool; tries every bolt and nut to see if they are secure, and then lifts the oil guards to be sure that the parts out of sight are tight and secure; moreover, he makes certain that all drips are open, that the oil flows freely in the pipes and channels and that the lubricator is shut off with the oil. He then examines the boiler before leaving to make sure that the fire is properly banked, the damper closed, the ashpit doors closed and the fire doors open; that the proper amount of water is in the gage glass and that the valves to the water glass are closed for the night. The feed pump should also receive attention.

In the morning, the same man will enter the boiler room and open the gage-glass cocks, note the water level and then start the fire; and while steam is rising he will examine the engine again to note that it is in the same condition in which he left it the night before. He will also take sufficient time to warm the engine before throwing on the full load.

Some operators contend that after working long hours in hot engine rooms they should leave as soon as they can stop the engine and see that the fires are banked. The writer still contends that, in the long run, the operator will lose more time by this method than by a proper system of inspection. The operator often terminates his employment by lack of this same system.

Again, when the plant is in operation, it is well to regularly, once a day, test the safety valve by raising it from the seat to see that it is not stuck. Many explosions could be prevented by this practice.

Also, a log sheet plays an important part in this system, and even though simple, it is an aid; one in which the steam pressure is noted hourly, and the daily consumption of fuel and oil is recorded. If the steam pressure is notated hourly it, if nothing more, insures the fire room being visited just that often if the readings are taken conscientiously; if they are not, then there is no system. If the operators have not the time to take readings every hour, let them do so as often as they can, and when they must skip a regular reading, let them leave the space on the log sheet for that time blank. The recording of pressures on a log sheet also serves the useful purpose of forming habits of observation as do the inspections already mentioned. Observation is one of the most useful qualities required of a successful operator and manager.

An operating engineer, who some 16 years ago was an assistant in a power house in the vicinity of New York City, had a series of experiences lasting over a period of six months which aptly illustrates the good of "scientific management" applied to the engine room. He

had erected the engines in this plant, and was then engaged by the management to act as repair man and first-assistant engineer. As in many places, there were cliques formed in this plant among the older men, who did many things to put the younger newcomers in tight situations. The chief was a man who did not believe men would play serious tricks on one another, nor would he stand tale bearing unless backed by absolute proof. This is a good rule for any man in charge to follow, and in the end it resulted in the greatest good to the young first assistant from the training he received.

This was a combined electric light and railway plant, operating 24 hours per day, and the work was divided into three 8-hour watches. The relief watches were instructed to come on a half hour earlier, and after changing his clothes, each man inspected the plant in company with the man he was relieving until satisfied that he knew all he should of conditions, and then accepted the plant to operate his shift. It was this practice that the first assistant had to cultivate thoroughly in order to avoid trouble.

He stood a regular watch along with the two other assistant engineers, and performed much of the repair work and keying up with some of the assistants while standing his watch. One day he came on watch, and after going the rounds with the man he was to relieve he accepted the plant and went about the regular duties of operation. Soon after the man whom he had relieved had left the plant, one of the oilers came to him and said that the main bearing of one of the largest engines was hot, and that this engine had been shut down a few minutes prior to his coming into the power house.

It was intended that the first assistant should start this engine and sandpaper the commutator of the generator which was belted to it. Too frequently do engineers fall into the habit of starting engines and sandpapering the commutator of the generators without turning on the oil. This is a bad practice, but was in vogue nevertheless.

As soon as the oiler reported that the main bearing was hot, the engineer felt of the bearing, something he should have done while he was making the rounds with his predecessor. He found the main bearing so hot that he could not hold his hand on any part of the box, and the main shaft was by this time also heating to the same extent, some little distance outside of the bearing. The engineer then lifted the plungers of the oil cups and allowed them to drop into their usual notch; this showed that the men who had been running the engine knew that the main bearing was hot, for the feed was so adjusted that the oil was running from the oil cups in a stream into the bearing. It also showed that the crew which had just been relieved had a guilty knowledge of the condition of the bearing, and had gone off watch without reporting it, hoping that their relief would start the engine and sandpaper the commutator of the generator without going near the bearing, and thus they would be able to place the blame upon those who sandpapered the commutator. Of course, the engineer had the bearing stripped and the babbitt was found to have been "pulled." It necessitated the whole main bearing being stripped and the oil grooves chipped out at the top and bottom and in the quarter boxes, and the whole bearing rescraped.

Another custom in this power house had to do with the starting of the Corliss engines. At this time, the first assistant followed the custom of starting the engine by admitting enough steam to just turn it, and then taking the starting bar, he would "rock" the piston backward and forward a few times in order to thoroughly warm the cylinder and work out any water which might be entrained. One day, he started the engine as usual soon after coming on watch, and after rocking the piston a sufficient number of times, he hooked in the reach rod on the wristplate and let the engine start off on its travel. Just as he hooked in the rod, however, and the engine went over the first center, he noticed that there was considerable play in the reach rod; that it seemed to have much more lost motion than he had ever noticed before. He immediately brought the engine to a stop and, looking over the valve gear, found that the pin connecting the reach rod with the rocker arm had backed off so far that the nut on the reverse side of the rocker arm was only holding the pin by about one thread; and if the engine had been allowed to come up to speed, and before the load had been thrown on, the nut would have worked off and allowed the pin to fall out of position, probably resulting in a wrecked valve gear. The amount of damage it would have done would have depended largely on how closely the engineer was watching everything while starting up.

In this same plant were two vertical cross-compound engines of 500 and 800 horsepower respectively. These had oil guards on the sides of the frames which shut out from view the crosshead as it worked up and down between the guides. The oil for all the pins and bearings was supplied from a reservoir from which pipes ran to the various points where oil was needed; one pipe ran inside of these guards and dropped the oil into a receiver on the crosshead from which the oil was carried through a pipe down the connecting rod to the crank pins. The oil catches on the crossheads were only ¾ inch in width, and if the pipe was out of line the crank pin was likely not to get the proper lubrication.

After starting the engine one day, and while still running it slowly before throwing in service, the first-assistant engineer looked under the oil guards up at the oil pipes and found that they had been bent several inches out of line, and that the oil leading to the crank pin and also to the crosshead guides was not running anywhere near where it should. As these were high-speed engines, it is evident that much damage would have resulted by running five or ten minutes in such a condition.

These instances show that if the engineer who was coming on watch had not been careful to look over every part of the engines before relieving the other man, he would not have been able to place the blame where it belonged. It was his method of starting up cautiously that saved him from more disastrous results for which he would have received the blame from the chief engineer.

As previously mentioned, keeping a log book not only furnishes data from which the operating results can be computed, but it also requires the engineer to go about the various parts of the plant at stated intervals.

This was deemed so important in the plant under discussion that it was finally made a rule that the engineer in charge of a watch was to go into every part of his plant at stated periods to take the readings and inspect the plant.

At one time, soon after a new addition had been put in, many of the flanges on the high-pressure steam mains began to give out, and the first discovery of a cracked flange was made while the engineer was going to a certain part of the cellar to read a vacuum gage on a condenser. While passing along the pipe alley to get to this gage, he heard steam hissing from some place from which he knew it had not come before, and following the noise, he discovered a cracked flange on a 16-inch high-pressure steam main.

Another time he was going to a different part of the same cellar and discovered that one of the laborers who worked around the plant during the day was sound asleep in the bottom of a 20-foot flywheel of a Corliss engine which was to be started within a few minutes. As the flywheel was covered over by the flooring in a manner which permitted only the spokes and rim to come through the floor, it is evident what would have happened to the man; besides, the company would have been liable to a lawsuit.

Most all large power stations and steamships have a thorough system of inspection both at the time of changing watches and during each watch, which follows out the lines herein suggested. But it is in the small plants in factories and office buildings that there seems to be the greatest lack of such a system, and if every engineer who is in charge of a plant would think this over carefully and follow out the suggestion of careful inspection at all times, there would be fewer accidents and shutdowns would be reduced to the minimum.

Stresses in Locomotive Boilers

By W. H. Burleigh

Under the new regulations of the Interstate Commerce Commission, locomotives are required to be inspected at stated periods and the reports forwarded to Washington.

The computations contained in these reports are facilitated by the use of certain tables and formulas which are herein given.

Herein are set forth a few of the formulas and methods used by a prominent Western railroad in complying with the new boiler-inspection law of the Interstate Commerce Commission, which went into effect on July 1, 1911. This order requires a monthly inspection of every locomotive boiler and a report of this inspection to be sent to Washington; also, yearly reports of the condition of the interior and exterior shell, braces, stays, bolts and seams are required. At this inspection the boiler is subjected to a hydrostatic pressure of 25 per cent. above the working steam pressure.

A specification card for each boiler is required and this card includes the general dimensions and stresses in the most important members of the boiler. In calculating these stresses, the work of computation is considerably shortened by use of the accompanying tables. Table 1 shows the area supported by staybolts, crown stays and crown-bar rivets for various longitudinal and transverse pitch,

TABLE 1. AREA SUPPORTED BY STAYBOLT

Pitch of Staybolts, Inches	Pitch of Staybolts, Inches: 3½	3 9/16	3⅝	3 11/16	3¾	3 13/16	3⅞	3 15/16	4	4 1/16	4⅛	4 3/16	4¼	4 5/16	4⅜	4 7/16	4½
3½	12.3																
3 9/16	12.5	12.7															
3⅝	12.7	12.9	13.1														
3 11/16	12.9	13.1	13.3	13.5													
3¾	13.1	13.4	13.6	13.8	14.0												
3 13/16	13.3	13.6	13.8	14.0	14.3	14.5											
3⅞	13.6	13.8	14.0	14.3	14.5	14.8	15.0										
3 15/16	13.8	14.0	14.3	14.5	14.8	15.0	15.3	15.5									
4	14.0	14.3	14.5	14.8	15.0	15.3	15.5	15.8	16.0								
4 1/16	14.2	14.5	14.7	15.0	15.2	15.5	15.7	16.0	16.3	16.5							
4⅛	14.4	14.7	14.9	15.2	15.5	15.7	16.0	16.2	16.5	16.7	17.0						
4 3/16	14.7	14.9	15.2	15.4	15.7	16.0	16.2	16.5	16.8	17.0	17.2	17.5					
4¼	14.9	15.1	15.4	15.7	15.9	16.2	16.5	16.7	17.0	17.3	17.5	17.7	18.1				
4 5/16	15.1	15.4	15.6	15.9	16.2	16.4	16.7	17.0	17.3	17.5	17.8	18.0	18.3	18.6			
4⅜	15.3	15.6	15.9	16.1	16.4	16.7	16.9	17.2	17.5	17.8	18.0	18.3	18.6	18.9	19.1		
4 7/16	15.5	15.8	16.1	16.4	16.6	16.9	17.2	17.5	17.8	18.0	18.3	18.6	18.8	19.1	19.4	19.6	
4½	15.7	16.0	16.3	16.6	16.9	17.2	17.4	17.7	18.0	18.3	18.6	18.8	19.1	19.4	19.7	20.0	20.3

while Table 2 gives the diameter of the bolts and the areas at the root of the threads, minus the area of the telltale hole, which is 3/16 inch in diameter by 1¼ inches deep and is drilled from the outside in all short staybolts. This gives the area at the smallest section of the bolt and is calculated using the sharp V-thread.

The following notation is used in connection with the formulas:

P = Boiler pressure in pounds per square inch;
S = Stress in pounds per square inch;
S' = Shearing stress on rivets in pounds per square inch;
T = Tensile strength of plate in pounds per square inch;
T' = Tension in plate seam of lowest efficiency;
D = Diameter of boiler in inches;
J = Area in square inches supported by longitudinal stayrods;
A = Area of longitudinal stayrod or gusset plate in square inches;
E = Lowest efficiency of longitudinal seam;
E_p = Efficiency of plate;
E_r = Efficiency of rivets;
E_{pr} = Efficiency of plate and rivets;
F = Factor of safety = 4;

TABLE 2. AREA OF STAYBOLT, ROOT OF THREAD, LESS TELLTALE HOLE

Diameter, Inches	Decimal Equivalent, Inches	Area, Inches	Diameter at Root of Thread, Inches	Area at Root of Thread, Inches	Area at Root of Thread, Less Telltale Hole, Inches
¾	0.75	0.44179	0.6057	0.2881	0.2605
25/32	0.78125	0.47937	0.63695	0.3186	0.291
13/16	0.8125	0.51849	0.6682	0.3506	0.3230
27/32	0.84375	0.55914	0.69945	0.3842	0.3566
⅞	0.875	0.60132	0.7307	0.4193	0.3917
29/32	0.90625	0.64504	0.76195	0.4559	0.4283
15/16	0.9375	0.69029	0.7932	0.4941	0.4665
31/32	0.96875	0.73708	0.82445	0.5338	0.5062
1	1.0000	0.7854	0.8557	0.5751	0.5475
1 1/32	1.03125	0.83527	0.88695	0.6178	0.5902
1 1/16	1.0625	0.8866	0.9182	0.6622	0.6346
1 3/32	1.09375	0.93957	0.94945	0.7079	0.6803
1⅛	1.125	0.9940	0.9807	0.7554	0.7278
1 5/32	1.15625	1.05025	1.01195	0.80428	0.7766
1 3/16	1.1875	1.1075	1.0432	0.8547	0.8271
1 7/32	1.21875	1.16659	1.07445	0.90669	0.87909
1¼	1.25	1.2272	1.1057	0.9602	0.9326
1 9/32	1.28125	1.2893	1.13695	1.0152	0.9856
1 5/16	1.3125	1.353	1.1682	1.0718	1.0442

(3/16 inch telltale hole = 0.0276 square inch area.)

a = Area of rivet hole in square inches;
a' = Area at root of thread in square inches;
c = Area of telltale hole in square inches;
h = Pitch of stays, longitudinal axis of boiler;
i = Pitch of stays, transverse axis of boiler;
p' = Pitch of rivets;
p = Pitch of outer row of rivets;
t = Thickness of plate;
d = Diameter of rivet hole in inches;
n = Number of rivets in half the joint.

To bring a boiler within the required limits of safety, it is necessary to determine the maximum pressure at which the boiler can be safely worked. The law requires that on and after January 1, 1912, the lowest factor of safety allowed will be 4. Then in the following formula F equals 4 and

$$P = \frac{T \times t \times E}{\frac{D}{2} \times F} \qquad (1)$$

The value E may be determined by analyzing the longitudinal joint for failure in various ways. In a double- or triple-riveted butt joint as in Fig. 1, the joint may fail by one of three ways: First, a tearing of the plate along the outer row of rivets; this section of the plate, minus the diameter of the rivet holes as compared with the whole section of the plate, gives the efficiency, or

$$E_p = \frac{p - d}{p} \qquad (2)$$

Second, it may fail by shearing all the rivets in the joint,

$$E_r = \frac{anS'}{ptT} \qquad (3)$$

Third, by a tearing of the plate along some inner row of rivets and a shear of one or more rivets in the outer row, in which case

$$E_{pr} = \frac{(p - nd)tT + anS}{ptT} \qquad (4)$$

The lowest of these efficiencies is taken as the representative strength of the

joint when compared with the whole section of the plate. Some of the seams are welded for a short distance at both ends, but this is not considered in determining the efficiency of joints.

In double- and quadruple-riveted lap joints, Fig. 2, or in fact any lap joints,

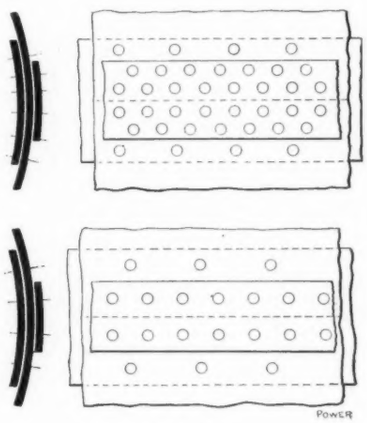


FIG. 1

there are two methods of failure considered, that of tearing of the plate and the shearing of the rivets, and the efficiencies are found by using formulas 2 and 3. In applying the formulas to the lap joint, however, the total number of rivets across the joint is considered.

A joint that presents a high efficiency is the Vauclain joint, shown in Fig. 3. Here the pitch is taken as the distance between the inner rows of rivets of two girth seams and the efficiencies are calculated by the same methods and formulas as are used for double- and triple-riveted butt joints.

The maximum stress to which a staybolt is subjected at the root of the thread is given as

$$S = \frac{P \times h \times i}{a' - c} \qquad (5)$$

The quantities $h \times i$ and $a' - c$ can be taken direct from the tables and thus save much mathematical work.

In calculating the stresses in the longitudinal stayrods, the area supported is taken as the segment of a circle, the arc of which is about 3 inches from the shell and the chord 2½ inches from the top of the uppermost row of flues. By measuring the rise of this segment and the length of the chord, the total area can be computed from the table of areas of segments found in "Kent's Handbook."

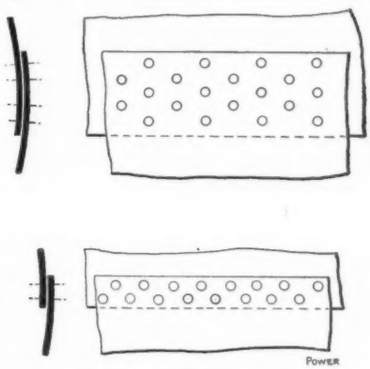


FIG. 2

The areas of all the rods are added together and the pressure multiplied by the area of the segment, divided by the total area of the rods will give the stress per square inch in the rods; or the stress in longitudinal stayrods or gusset-plate braces, expressed by formula, is

$$S = \frac{P \times J}{A} \qquad (6)$$

The area A is taken as the sum of the areas of the rods or the least section of the plate, in plate braces generally through the angle fastening to the heads where the diameter of the rivet holes are taken from the whole section of the plate.

The Interstate Commerce Commission allows double shear to be taken as twice that of single shear; hence for a longitudinal seam,

$$S' = \frac{P \times D \times p}{2 \times n \times a} \qquad (7)$$

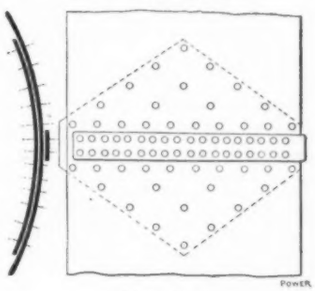


FIG. 3

where n is the total number of rivets in single shear, including each rivet in double shear being considered as two in single shear.

The quantity which in the majority of cases determines the factor of safety of the boiler is the tension in the plate seam of lowest efficiency and is calculated as follows:

$$T' = \frac{P \times D}{2 \times t \times E} \qquad (8)$$

where E is the lowest efficiency of the plate or rivets as compared with the solid plate. From this the factor of safety is found by dividing the minimum tensile strength of the plate by the tension in the plate as found in formula (8).

By the use of the foregoing formulas and tables, it becomes a comparatively simple process to fill out the required specification card for any locomotive boiler.

Causes and Prevention of Corrosion

By L. B. Taylor

General conditions controlling rusting. Presence of both oxygen and water necessary.

CO_2 increases the rate of rusting.

Dissimilar metals and dissimilar alloys in physical contact under water, especially salt water, are corroded by galvanic action.

Distilled water rusts iron more than do other kinds. Steam as such does not attack iron. Both water and oxygen are necessary to produce rusting. If iron is suspended in a vacuum above water (as in Fig. 1), no rusting will occur because there is no oxygen present. Paint is the only agent available for protecting iron against rusting.

Effect of the Supply of Oxygen on Rusting

The rapidity of rusting of iron in water is proportional to the amount of oxygen present. If the iron is near the surface of the water as in Fig. 2, rapid rusting develops, whereas if the iron is at a greater depth below the surface as in Fig. 3, the rusting will be much slower. In the first case, the oxygen of the air above easily diffuses through the water and attacks the iron, while in the latter case, the greater head of water above the iron diminishes the diffusion of the oxygen. Similarly, the rapidity of rusting depends on the surface of the water exposed to the air. Thus, in Fig. 4, the rusting will be relatively slow compared to the case in Fig. 5, where the iron is at the same depth below the surface, but the amount of water surface exposed to the air is much greater, which permits a greater amount of oxygen to diffuse through the water and reach the iron. In the latter case the rusting may be 30 to 40 per cent. faster than in the former.

Pure oxygen on the surface of the water, in place of air, can rust the iron as much as three times as fast. Spreading a layer of oil over the surface of the water offers no protection, as was once supposed, since the oil has a great solubility for oxygen.

If air is forced through the water (infusion of air under pressure) the rapidity of rusting can be doubled. Likewise, if compressed air exists above the water the rusting will be more rapid.

Rusting is naturally greatest at those places where the supply of oxygen is greatest; thus, for example, a suction pipe protruding from the water, as in Fig. 6, is attacked the strongest at its point of entrance into the water; that is, at the water level. Here a rust sponge is formed, which in itself offers an easier passage for the oxygen of the air than is offered by the diffusion through the water necessary to reach the other parts of the pipe line.

Since water has a greater ability to absorb oxygen than nitrogen, air sacks are to be considered as places in which a greater concentration of oxygen exists than in the air, and therefore where more intense corrosion occurs, especially if, by a continuous supply of fresh water containing air, there is a constant renewal of the oxygen. A few often recurring examples will illustrate this action.

On a vertical pipe the flanges deflect the upward currents of water and air sacks are formed at the places indicated in Fig. 7; consequently more rapid corrosion results at such places. In large water pipes, if the bend is too abrupt and the velocity high, the water does not flow in parallel streams around the curve but leaves the pipe as indicated in Fig. 8, where an air sack or partial vacuum exists. The greater concentration of oxygen helps in attacking the pipe at the inside of the bend and, as the place is constantly washed clean of rust by the flowing water, the bend is soon eaten through. The remedy, of course, is longer bends, or guiding ribs as shown in Fig. 9, for combing out the streams of flow and keeping them parallel, a method for which a patent has lately been granted.

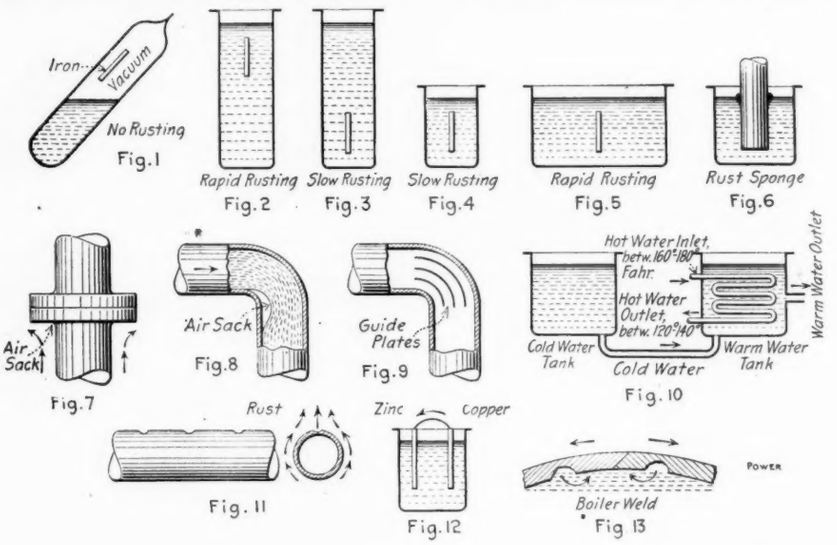
Fig. 10 shows the arrangement of a hot-water reservoir, the heating coil of which was ruined in practical operation by being eaten through in 20 to 30 days, as shown in Fig. 11. The process of rusting may be explained as follows:

The cold water contains air in solution, which, by the warming up of the water, separates out to the same degree as the decrease in solubility. Consequently, deaëration is caused by the contact of the cold water with the lower coils of the heating coil. The rising air bubbles so liberated, increasing constantly in number as the cold water continues to circulate, stick fast to the iron heating coil, especially at those places where a roughness already exists. Air and water act simultaneously on the iron, and rusting begins. The air bubbles, liberated by the further deaëration, stick fast at the rusted places so formed, which in comparison to the other parts of the pipe surface become very rough, thus causing a greater and greater spreading and deepening of the rusted surface, until finally, a complete rusting through occurs.

A comparison of two pumping plants using the same water developed the important fact that in the one where pumping was done continuously the rusting was slower than in the other, pumping intermittently. The explanation of this is that in the latter more air mixes with the water during the pauses and this air aids considerably in the rusting.

Recognizing that oxygen is the real cause of rusting, means should be taken to rid the water of it, or to render it harmless by otherwise combining it before it enters the water pipes. By boiling the water or by pumping out, the oxygen can be entirely removed, or greatly reduced in quantity, but these means can hardly come into consideration for large-sized commercial plants since they are too difficult and costly.

Tests made by suspending charcoal in the water or by using charcoal for a filtering material to remove the oxygen from the water have led to good results. Here the well known principle is utilized, that charcoal induces gases to precipitate on itself and holds them fast. Naturally it is important to use the deaërated water immediately or, in case this is not possible, to guard against resaturation with air. Quantitatively, if it is assumed that 100 cubic centimeters of water saturated with air contains 0.8 cubic centimeter (that is, nearly 1 per cent. by volume) of oxygen (at 0 degree Centigrade and 760 millimeters barometer), corresponding to 0.00114 gram of oxygen, then every million gallons of cold fresh water can convert, in the ideal case, 45 pounds of iron into ferric-oxide.



Effect of CO_2 on Rusting

This has in the past been overestimated. Rusting can occur without CO_2. Air containing as much as 15 per cent. of CO_2 acts only twice as fast as air without any CO_2. Pure CO_2 alone cannot rust iron. The previous theory why water pipes rusted was that the CO_2 dissolved in the water converted the iron into carbonic-acid-ferrous-oxide; the oxygen of the air in the water then changed the dissolved ferrous oxide into insoluble ferric hydroxide by precipitating the CO_2, which again attacks the iron.

Galvanic Action and Corrosion

It is known that in salt water the materials common in machine construction, zinc, aluminum, iron, tin, iron-bronze, pure aluminum-bronze, ferric aluminum-bronze, pure tin-bronze (89 Cu 11 Sn), bronze low in zinc (88 Cu, 8 Sn, 4 Zn), copper, phosphor-bronze (94 Cu, 6 Sn with Ph), are corroded by the galvanic currents developed as soon as they come into metallic contact with each other. When metallically connected, a current flows from any material listed toward the end of the above series to any one preceding it, which flows back through the water from the material nearer the beginning of the series to the other metal, whereby the material from which the current flows on entering the liquid is eaten away or corroded. Fig. 12 illustrates the principle, the plates being labeled zinc and copper merely by way of illustration. Thus, by a galvanic element of two different metals and water, that metal is as a rule most strongly attacked which stands nearest the zinc in the series given above. The arrangement of the series of metals in the order of their voltages depends on the liquid used. The series must therefore be determined individually for each liquid. The fact that when iron under water is in contact with zinc the rusting of the iron is considerably reduced or completely overcome, has long been used in practice for boiler plants, especially on ships, as well as in condensers and pipe lines.

An interesting discovery of the cause of boiler plates corroding near the weld is that if the plates are overheated in welding and are not hammered until they have reached red heat, when put into use a current is set up as indicated in Fig. 13. The current

flows from the normal part of the plate through the water to the previously overheated joint and back through the plate. The metal is corroded as indicated where the current passes from the plate to the water.

Effect of the Composition of Metals on Galvanic Action

The following tests, conducted at the German government laboratory, on the influence of the contact of different metals with iron, show the general tendencies, although they are only exactly true for the special conditions under which the tests were conducted.

Iron in contact with copper was rusted in fresh water 25 per cent. faster and in artificial salt water 47 per cent. faster than if by itself. The conclusion is drawn that by means of the copper the oxygen dissolved in the water acts on the iron electrode with a greater intensity than if the contact with the copper electrode did not exist.

With reference to the contact of iron with nickel, tests conducted with distilled water showed that the iron was coated with 14 per cent. to 19 per cent. more rust than when not in contact with the nickel. A homely illustration of this is shown by the fact that the steel blade of a safety razor rusts much faster, if left wet, in contact with its nickel-plated holder than it would by itself.

With cast iron in contact with a piece of welded steel pipe, tests at room temperatures showed that the steel was strongly protected by the cast iron. With air passing over the surface, the rusting was reduced 50 per cent., and by air passing through the water it was reduced 28 per cent. The same tests at temperatures between that of the room and 140 degrees Fahrenheit, using well water, showed that the rusting of the steel was reduced 16 per cent. on the average, at the cost of the cast iron. The idea that cast iron by itself rusts less than steel by itself is not true. There is not much difference in the rapidity of rusting between cast iron, wrought iron or steel. The scale on iron castings and their greater thickness of wall may make them last longer.

Phosphorus and Nickel in Steel

If a steel high in phosphorus is in contact with one low in phosphorus in salt water, the former will be protected and the latter will rust faster. Nickel in the steel has a similar effect. From this the conclusion is drawn that steels with important differences in composition should not be connected if external conditions favor a galvanic element.

Copper Alloys

An alloy high in zinc is attacked considerably faster in salt water than in air, and still more so if it is in contact with other metals. The corrosion of copper alloys with 24 per cent. zinc takes place, by the galvanic current, if it is in contact with copper or alloys high in copper, almost as it would on other copper alloys, principally from the outside. With 28 per cent. or more zinc the corrosion is considerably greater. By adding 15 per cent. nickel, copper alloys high in zinc will be better protected against corrosion.

Developments in Prime Movers

Steam Turbines

By A. G. Christie

Continuation of article in the September 12 issue. In the present instalment European practice in steam turbines, condensers, electrical apparatus, gas engines and oil engines is reviewed and compared with American methods.

The steam turbine for power-plant work has been developed in Europe with great rapidity within recent years, so that almost every large engine builder is now able to furnish steam turbines. In Germany the impulse type of turbine is built almost exclusively, while in England and Switzerland the modified reaction type seems to be in the lead. Fig. 1 shows a section of the Zoelly turbine, which is characteristic of the German impulse types. It is built by Escher, Wyss & Co., Gorlitzer, Frazer & Chalmers, James Howden & Co., John Brown & Co., Oerlikon, Sautter, Harle & Cie, and several other firms.

The Curtis turbine has been built by a number of firms in Europe, but it has been superseded to a large extent by the combined type of turbine which is now being largely constructed in Europe and which has been very fully described in recent issues of POWER in the articles by F. E. Junge and E. Heinrich. This type of turbine, a sample of which is shown in Fig. 2, consists of a Curtis high-pressure stage combined with either a Zoelly or a Rateau low-pressure element. It is claimed for this type that there is no high temperature inside the casing as the temperature is reduced in the nozzles and in the first revolving blades of the Curtis element. Also, it is not necessary to provide high-pressure packing on account of the decreased pressure in the turbine after the steam has been expanded in the nozzles. The clearance can be made quite large, hence the machine will not be subject to mechanical defects or blading troubles. The Curtis high-pressure section seems to have proved the most economical construction for the utilization of high-pressure steam, while either the Zoelly impulse or the Parsons type seems to be the most economical in the low-pressure section. The combined-impulse type, with the Curtis high-pressure section, is now being manufactured by the Allgemeine Elektricitäts Gesellschaft, the Bergmann Elektricitäts Gesellschaft, the British Thomson-Houston Company, and the British Westinghouse Company. The modified-reaction type is manufactured by almost all the companies which formerly built the straight Parsons turbine, and among these are Brown, Boveri & Co., Melms & Pfenninger, Willans & Robinson, C. A. Parsons & Son, Franco Tosi, Gebruder Sulzer and the Erste-Brunner Company.

One of the officials of Brown, Boveri & Co. recently stated that they had found that the modified reaction type gave an increase in economy of 10 per cent. on low-speed turbines over the old Parsons type and an increase of about 4 per cent. on the high-speed turbines. It is claimed for these modified turbines that there is less distortion of the cylinder due to high temperatures than in the old Parsons machines; also, when the Curtis stage is used in the high-pressure section the machine can be made shorter and is more perfect mechanically since the distance between centers is less, and the spindle can be made rigid. The high efficiency of the Curtis stage for high-pressure steam is combined with the high efficiency of the Parsons stage for low-pressure steam, so that the resulting unit is more satisfactory in operation than either the straight Curtis or the straight Parsons types.

The governors used on these turbines are generally of the Hartung type, such as is used in this country on the Allis-Chalmers steam turbine. Governing is effected by throttling the steam through the medium of oil-relay valves. On the impulse turbine extra nozzles are opened by hand for the heavier loads with the exception of some of the newer Allgemeine Elektricitäts Gesellschaft turbines, where these are opened by the governor. The writer did not notice any switchboard speed-control devices on any of the turbines in the power plants throughout Europe. This is quite common practice in America.

The blading of many of the impulse turbines is completely cut from solid metal by means of milling machines and their special cutters. This insures very

homogeneous material and also overcomes the difficulties frequently met with from straining the material by forging it or pressing it into shape. In the Bergmann turbine, however, sheet-metal blades are used throughout, the distance pieces between the blades being of drop-forged brass. These sheet-metal blades are held to the disk by rivets and form a very rigid and apparently economical construction.

Turbo-generators

The tendency throughout Europe is to utilize higher speeds for steam turbines with a view to attaining more economical results. As excellent steel forgings can be obtained cheaply in Europe, the rotors of the generators can be run at high speeds. The stators in some machines do not seem to be of very good construction as compared with American practice as the windings appear to be rather loosely put in and the installation is not up to our standards. The Bergmann company manufactures a large number of direct-current machines with heavy steel rings shrunk on the commutators. Interpoles are also used to prevent sparking at the brushes. However, these machines are extremely noisy and do not seem to fulfil the ideal requirements of a direct-current turbo-generator. An interesting departure from standard practice is shown on the Westinghouse direct-current turbo-generator, which is provided with a radial commutator so that the evil effects of centrifugal force are largely overcome. This commutator runs very quietly and apparently has given good satisfaction, the only difficulty being to obtain sufficient commutation surface without crowding the brushes.

The accompanying table, page 630, shows the results of a number of recent European turbine tests which have been collected from various authorities and also a number of tests made on American turbines. The turbines showing the highest efficiencies are the 2000-kilowatt and the 6000-kilowatt units built by the Erste-Brunner company. These are of the modified Parsons type. The next turbine in the order of high efficiency is the Dunstan-Parsons, which was built by Brown, Boveri & Co. and is also a modified Parsons type. The fourth on the list is an American machine, the Allis-Chalmers unit at Richmond, Va. This is the first straight Parsons unit on the list. Following this comes the City Electric Company's Westinghouse machine, a double-flow unit, and the Brooklyn Rapid Transit's Westinghouse, double-flow machine, which are also modified Parsons units. From this it is seen that the turbines which have shown the best efficiencies in Europe and in America, with the exception of the Allis-Chalmers machine, have been those of the combined type. The manufacture of the modified types of turbines with the exception of the Westinghouse double-flow machine has not been taken up to any extent in this country, but in view of the success with which they have met in Europe, it would seem that their manufacture must be taken up in earnest before long in America.

Low-pressure turbines are being built to a large extent in Europe, but are being installed in old plants only or around collieries and rolling mills where engines have formerly been run noncondensing. In a few plants they have been installed where the engines are comparatively new and where it was not desired to throw the engines out entirely, but as a commercial proposition it is not considered desirable to install high-pressure engines and low-pressure turbines where a new plant is being built. This statement does not hold true for marine practice, where most of the more modern ships are being equipped with high-pressure steam engines and low-pressure turbines.

Condensers

In Germany a type of condenser is largely used in which bronze tubes are rolled into the tube sheets, the condenser shell being of boiler plate. It is claimed that the bronze tubes are cooled by water to a lower temperature than the steam temperature in the condenser, while the condenser shell is warmed to the same temperature as the steam itself. Hence, the expansion of the steel is relatively greater than the bronze tubes, so that in operation these two equalize one another and no trouble is experienced with leaking tubes due to expansion. In the Moabit station the writer was shown a condenser on a 4000-kilowatt turbine which had been in service for three years, and on which no repairs had been made to the tubes. The water supply for this condenser was taken from a neighboring canal and was not ideal by any means.

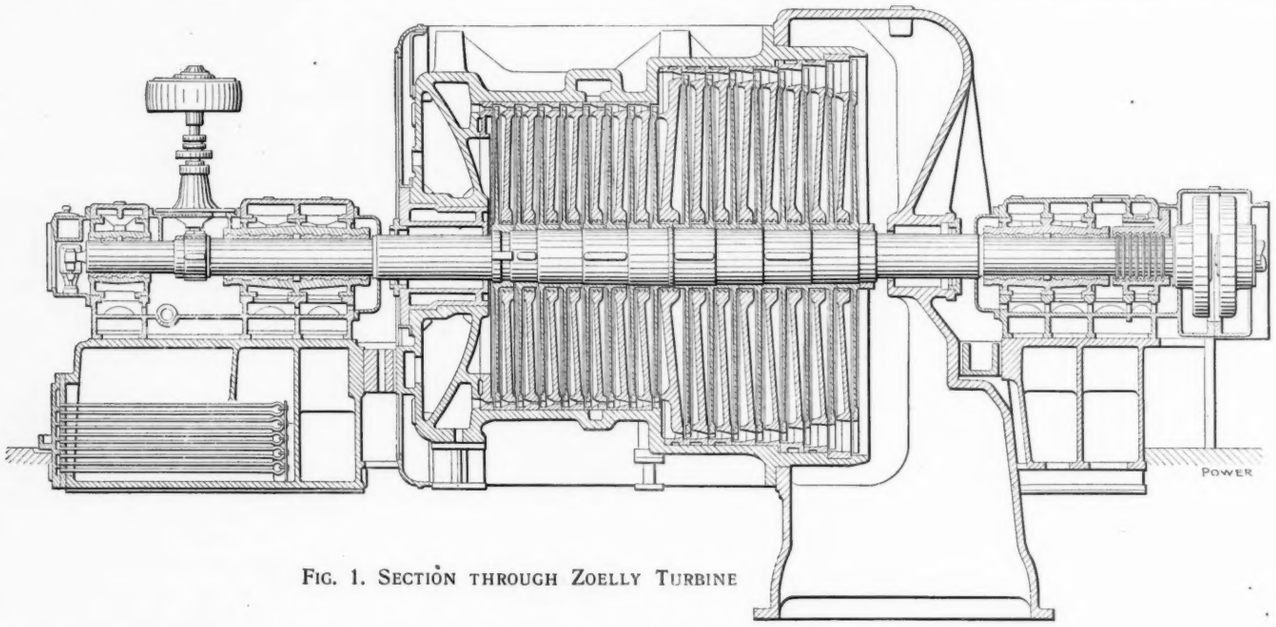


Fig. 1. Section through Zoelly Turbine

On the Continent rotary air pumps are used almost exclusively. Many of these are of the Le Blanc type, while others are of the type shown in Fig. 3, in which the air is pumped by the injector action of the sheets of water thrown out by a small centrifugal pump. Fig. 4 shows an installation in which rotary air pumps of the Allgemeine Elektricitäts Gesellschaft type are installed in connection with the main steam turbines. In England the three-throw Edwards air pumps are still favorites and are used almost exclusively in the larger plants. Many of the steam-turbine plants are equipped with Parsons vacuum augmenters and some remarkably high vacuums are obtained by this means, but the equipment with this apparatus and with the Edwards

pumps takes up much more floor space than the rotary air pumps of the Le Blanc type; it is doubtful whether they are more reliable or efficient in operation than the rotary type.

Cooling Towers

Cooling towers are very generally used throughout Europe. The majority of these are built to utilize natural draft. In Germany a large number are being built of reinforced concrete and are extended up to a considerable hight to provide a chimney effect which will increase the draft. They look very substantial and are quite in harmony with the architectural design of most German plants.

Electrical Machinery

The electric drive has not been applied so generally in England as in this country because of the conservative attitude of most of the mill people. The switchboards in the majority of power plants are built along the same lines as those employed in America. One station in the north of England is building all the switchboards of planished steel. The switches, which are principally of the relay type, are mounted on insulators on these boards. This construction is not only of pleasing appearance but is serviceable, is easily kept clean and is said to be cheap as compared with a marble board.

One notices the lack of switchboard speed control of the main units in almost all European power plants. Another noticeable feature is the lack of automatic voltage regulators in all stations except those of very large size. On the Continent practically all substations employ motor-generator sets instead of rotary converters. The electric motor has not been introduced in steel-mill practice to any great extent, although the Cockerill company has one rolling mill electrically driven. The generators furnished by several builders for connections to gas engines are provided with extremely heavy rotors, which take the place of flywheels and thus reduce the floor space required by the gas-engine unit. At one of the large steel works electric heaters are provided to heat the rims for shrinking on car wheels. This method is said to be much more rapid and less costly than the former practice of heating with gas, besides producing a more uniform heat throughout the rim.

The Siemens-Schuckert Company follows the practice, common in this country, of insulating the commutator seg-

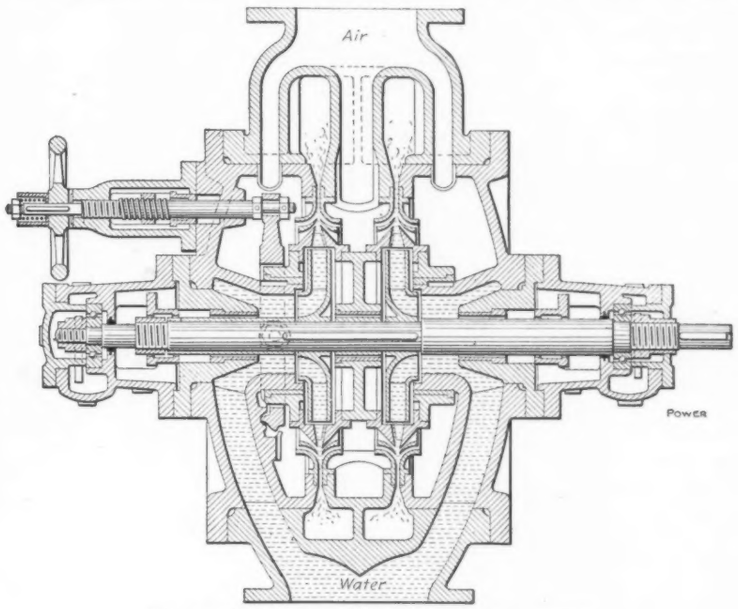


Fig. 3. Section through Rotary Air Pump

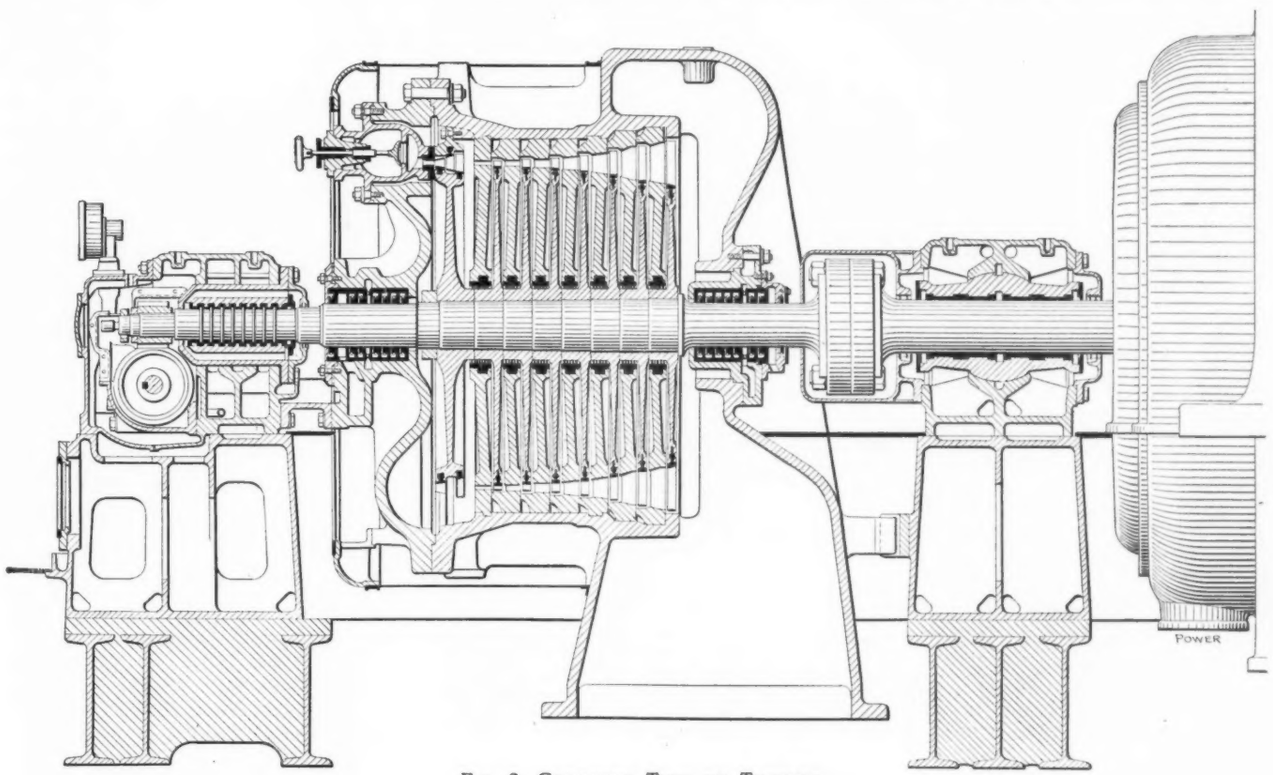


Fig. 2. Combined Type of Turbine

ments of its direct-current machines for only part of the depth, the outer radial section of probably ¼ inch between the bars being left open without insulating material. It is said that this does not collect dirt as the centrifugal force throws it out from between the bars; should dirt collect there, it can be easily cleaned when the machine is shut down. The advantage of this construction is that the brushes wear the bars evenly and there is less liability of sparking.

Another interesting construction followed by this company where large currents are to be taken off the commutators is to split the commutator in the center of its length and to connect the two halves by flexible copper connections. The outer half is built on a ring which stands out from the main shaft itself, and is provided with some small blades which force the air through the split portion of the commutator when the generator is in motion and thus assist in cooling the commutator segments. It is said that less commutator surface has to be provided and better commutation results than with the ordinary construction of the commutator.

This company also employs the vacuum system for impregnating its electrical machinery with the insulating compounds. It has a cylindrical shell of sufficient size to accommodate a large-sized

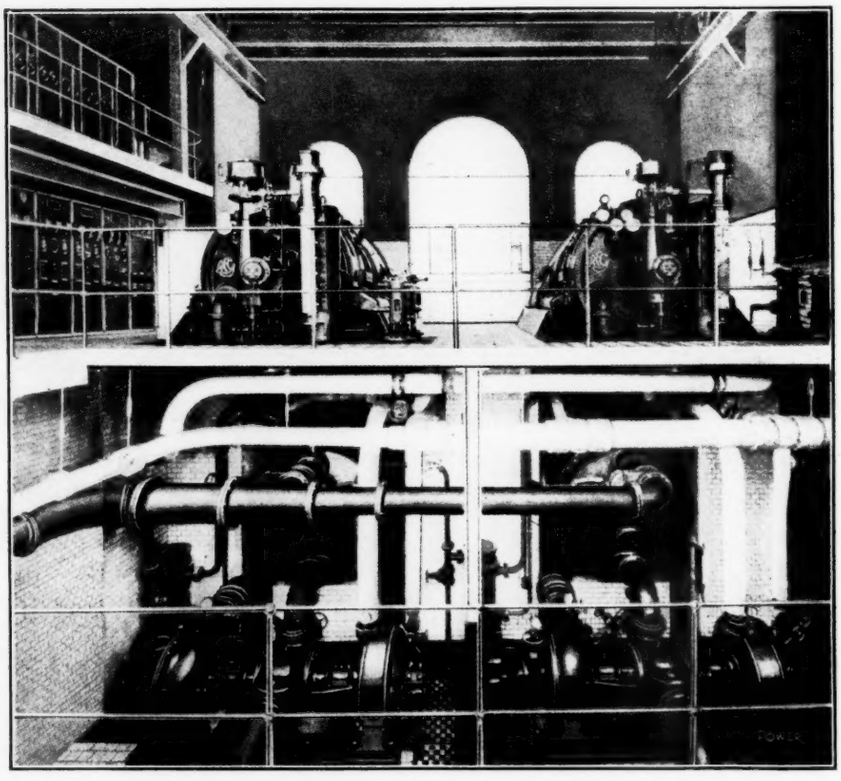


FIG. 4. POWER STATION OF A. E. G. FACTORY, BERLIN, SHOWING ROTARY AIR PUMPS

truck. Both heads of this shell can be closed and hermetically sealed. The interior of the shell is lined with the steam pipes, and the upper portion connects with a vacuum pump. The temperature of the interior is raised to about 250 degrees so as to evaporate any moisture which may be in the windings of the electrical machine placed on the truck. At the same time the vacuum produced will cause any air bubbles or pockets which may occur in the insulation to swell and expand and find a way to get out from under this insulation and be finally removed by the air pump. After the machine has stayed in this chamber for a sufficient length of time to insure the removal of all moisture and air, the air pump is shut off and the tank is allowed to fill with the insulating compound. The machine remains in this liquid for a time sufficient to insure the impregnation of all parts of the insulation, after which the compound is run off and the windings are dried. All large transformers for high voltage are treated in the same way.

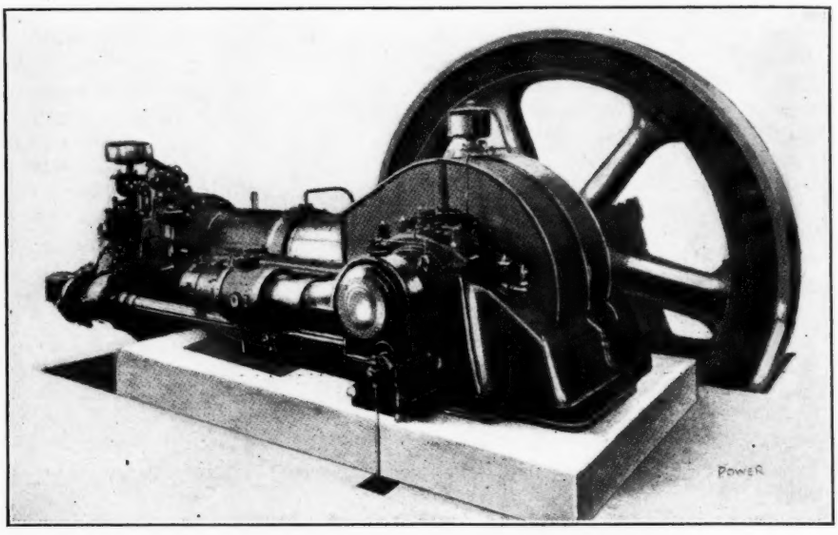


FIG. 5. HORIZONTAL TYPE OF DIESEL ENGINE

The city of Schaffhausen, Switzerland, has resorted to an interesting scheme in connection with its hydroelectric plant. There is a considerable fall of water available at this place, but it has been developed at several points by small mill owners and others who have installed old-fashioned, inefficient machinery in such a way that the full benefit of the fall is not had. The city was unable to arrange with these concerns whereby it could dam the river and develop the full head available; hence it had to be content with a certain amount of water at a small head to which it was entitled by its charter. In order to carry a maximum load with the flow available, the city constructed a concrete reservoir of 300,000 cubic meters on a hill adjacent to the town. It also installed in the plant some high-pressure centrifugal pumps which can be connected to the low-pressure turbines and which elevate the water from the river into this reservoir during the night and at periods when the load on the station is light. During the peak loads in the afternoon the water is drawn from this reservoir and passed through a high-pressure hydraulic turbine direct connected to a generator. It is estimated that the efficiency of this system is about 50 per cent., but the power costs in this neighborhood warrant its installation, and satisfactory results are said to have been obtained ever since the plant was installed.

The Stumpf Direct-flow Steam Engine

Professor Stumpf, of the Charlottenburg Technical High School, has introduced in Germany a type of steam engine known as the direct-flow engine which deserves careful attention. The results obtained have been so remarkable that the reciprocating engine is insured a new lease of life, at least in the smaller sizes. This engine was described in the January 31, 1911, issue of POWER.

Gas Producers

The suction-gas producer is very common in England, where anthracite coal is used almost invariably. These producers are nearly identical with those used in the United States except in certain features of detail and in the grate surface. With the English anthracite coal it is possible to use a much smaller grate surface than can be employed with American coals. Several attempts have been made to develop tar-free producers for bituminous coal in England, but of these, the only one which the writer noted in successful operation was that built by the Morton Gas Power Syndicate, of Manchester, England. This was a down-draft producer with a secondary air inlet at one side, which, owing to the construction of the producer, seemed to be providing tar-free gas, although a certain amount of lampblack was formed. The producer is built with rectangular sections, which is not common practice in the United States.

A considerable number of bituminous producers are used throughout England in connection with byproduct recovery plants. On account of the advanced state of chemical manufacture throughout Europe, these byproducts are of considerable value, especially the benzols, tars and ammonium sulphate. In Germany the gas producer is not nearly as commonly used as one is led to believe from reports frequently published in the technical press. In fact, the writer saw only a few producer-gas plants during his whole trip on the Continent. The Diesel engine, to which reference will be made later, seems to have replaced to a very large extent the producers formerly used on the Continent. Peat and lignite producers have been developed in Europe and some were being constructed, although none was seen in commercial operation.

Gas Engines

The small-sized gas engines built both in England and on the Continent embody many fine features of construction. As a rule, the frame is massive and heavy flywheels are also provided. The valve gear is mechanically controlled and the ignition is generally of the magneto type with a battery for starting. Many different methods of governing are employed, some of them of very interesting and excellent types. The large-sized engines built in England do not seem of as good construction as those built in America, and they compare most unfavorably with the ones seen in Germany. The large-sized German engines are probably the best built engines of their class in the world. Practically all of the engines driving electric generators are of the four-stroke cycle type. Many, if not all, of the blowing engines in the ironworks are of the two-stroke cycle type, of which particular mention may be made of the Oechelhauser, the Körting, the Siegener and the Ehrhart & Sehmer engines. The design of the firm first mentioned has been materially altered within recent years. The construction which it formerly used and which employed two pistons acting in opposite directions with three cranks on the shaft, has been abandoned in favor of a design following very closely the original Körting type.

The gas-cleaning systems in the ironworks of Germany have not been perfected to the same extent as those of similar plants in this country. The German engines seem to operate satisfactorily even with the much dirtier gas used at their plants, so that one is led to question whether the additional expense and trouble taken to clean the gas in American steelworks is justified by the results obtained with the engines. It is common practice in Germany to use grease lubrication on all pin joints on the gas engines and everywhere else that it is possible to use it.

The writer was furnished with figures on the cost of producing power at one of the large German steelworks, which, when transformed to American money, are as follows: 0.125 cent per kilowatt-hour, operating charges only; 0.2 cent per kilowatt-hour, operating cost, with cost of gas included; 0.4 cent per kilowatt-hour, including all costs, interest, depreciation and taxes. The cost of gas in the foregoing figures was based on an equivalent B.t.u. value in coal at $2 per ton.

Humphrey Gas Pump

The most interesting development in gas-engineering lines is the Humphrey gas pump, which was recently described in POWER.

Diesel Engines

Probably one of the most impressive engineering features in Europe is the phenomenal development of the Diesel engine. This is now seen everywhere, in hotels, department stores, factories and power plants. It is much more common than any other recent type of engine. In England the London Electricity Company has installed oil engines of the Diesel type to carry the peak loads at substations and thus relieve the power plant of excess capacity. The Berliner Elektricitäts Gesellschaft is also said to be considering a similar installation. Several large ships, notably the "Vulcanus," which has been described in recent engineering publications, and a new Hamburg-American liner of 3000 horsepower, have been fitted with Diesel engines. Altogether, 250 ships have been or are being fitted with this type. It has been rumored recently in engineering periodicals that the German navy is at the present time installing 10,000 horsepower of this type of engine on one of its new battleships. When the writer visited the Maschinenfabrik, Augsburg-Nürnberg, a 2000-horsepower, six-cylinder, vertical, double-acting Diesel engine of marine type was on test. This one was said to be intended for a ship of the German navy, although it was not made public on which one it would be installed.

Among the leading manufacturers of this type of engine in England are Willans & Robinson, Mirriless-Watson and Richardson-Westgarth; and on the Continent, the John Cockerill Company, Carels Frères, Schneider & Cie. The Maschinenfabrik, Augsburg-Nürnberg

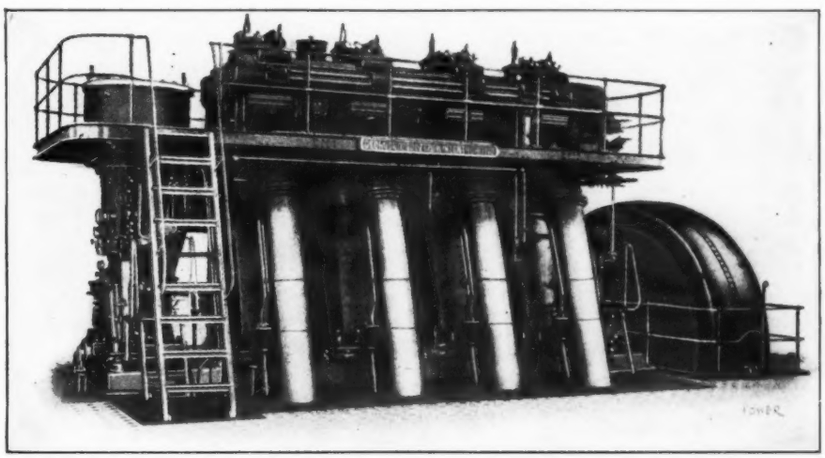


FIG. 6. 1500-HORSEPOWER TWO-STROKE VERTICAL DIESEL ENGINE

builds vertical two-stroke and four-stroke cycle units, and it is said to have built over 1700 Diesel engines up to the present. Within the last year it has developed a new horizontal type of engine, shown in Fig. 5, which follows the standard lines of construction of European gas engines. Quite recently the same company contracted for a 2000-horsepower horizontal engine for Halle on the Saale, Prussia. This unit will be a four-stroke cycle, double-acting, two-cylinder, tandem engine operating at 150 revolutions per minute and direct connected to a direct-current generator, coal-tar oil being supplied as fuel. The compression will be between 500 and 600 pounds per square inch.

Gebruder Sulzer have probably taken the leading position in the development of the Diesel engine in Europe. They are at present prepared to furnish vertical units ranging from 15 to 4000 horsepower of both two-stroke and four-stroke cycle types and also double acting. Fig. 6 shows one of these vertical engines of the two-stroke cycle type.

The latter type will probably supersede the four-stroke cycle type, especially on large engines. The reason for this is that the purging of the cylinder on a Diesel engine does not entail any loss of fuel even should a certain amount of incoming air pass out through the exhaust pipe. This is because the fuel is not added until the air in the cylinder has been compressed to maximum compression. In the vertical cylinders it is common practice to have the lower part of the cylinder act as an air compressor for the upper part and to provide an auxiliary compressor on the end of the shaft to make up the extra air necessary for the complete purging of the cylinder. It has been found that from 1.2 to 1.5 times the volume of the working cylinders is required to produce the proper scavenging and to provide a fresh charge of air for the next stroke.

Almost any kind of oil which can be pumped may be used in these engines as fuel. On the Continent, coal-tar oils are largely used, thus utilizing a byproduct from city gas works and that which had formerly been wasted by producer-gas plants. On these engines it is customary to start with kerosene or some other light oil and run until the engine is warmed up, when the fuel-oil pump is switched over onto the heavy oils. Only one fuel valve has been found necessary with all classes of oils, and only one is now installed on the engines.

The marine Diesel engines are now designed to correspond very closely to the standard design of modern steam engines. All parts are made accessible for repairs, and with no unnecessary weight. The pistons are, as a rule, cooled with oil instead of water, so that should any leakage occur there will be no damage done to any of the wearing parts. This oil is cooled in a separate cooler before recirculation in the pistons. The pistons themselves are now being made very much like the standard steam-engine pistons. In the land type of engines considerable discussion has recently taken place regarding the relative merits of the trunk piston as compared with the narrower steam-engine piston provided with guides and crossheads. It is probable that the latter type will be adopted and the engines will be made double acting. This avoids leakage of gas into the engine room and also makes the engine smaller for a given power. The fuel consumption of these engines ranges about 0.4 pound of oil per brake horsepower-hour.

The development of the Diesel engine in Europe has progressed much more rapidly than in America, and the details of the engine have been worked out so carefully that engines can now be so built and installed that no trouble will develop as regards their operating qualities. In every respect the reliability of such a type of engine is no longer questioned to any great extent on the Continent. With the large supply of liquid fuels in America and their low cost in certain sections, it would seem imperative that American engine builders consider this new type more carefully and develop it to the same extent that it has been developed in Europe. Steps have already been taken by several prominent companies in America, and it seems probable that in the near future engines with as fine records as the German engines will soon be common in American power plants.

ECONOMY TESTS OF ENGINES AND TURBINES

Based on Marks and Davis Tables

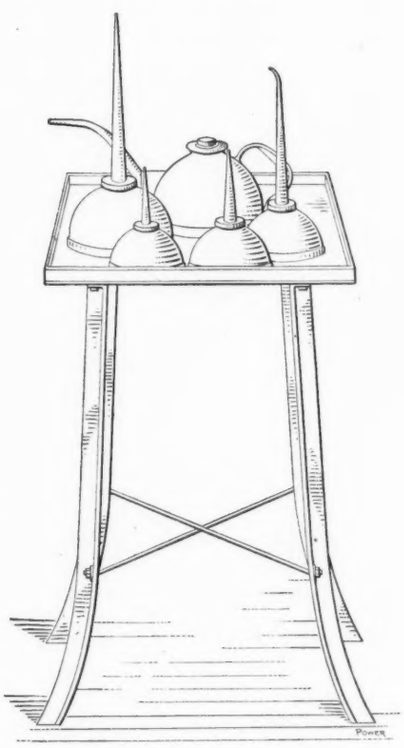
In Calculating Rankine B.t.u. an Efficiency of 90 Per Cent. is Assumed for the Turbine and Generator.

Turbines	Load, Kilowatts	Steam Pressure, Absolute	Superheat, Degrees Fahrenheit	Vacuum; 29.92-Inch Barometer	Pounds Steam per Kilowatt-hour	B.t.u. per Kilowatt-minute	Rankine Cycle, B.t.u. per Kilowatt-minute	Efficiency Ratio
Erste-Brunner	2,000	161.5	118.0	27.82	13.84	274.5	218.4	79.6
Erste-Brunner	6,000	191.0	194.0	28.12	12.58	259.5	205.6	79.2
Dunstan, Parsons	6,257	204.0	176.0	29.02	11.95	249.4	190.8	76.4
*Richmond, Allis-Chalmers	4,328	186.0	108.0	27.97	14.02	278.3	211.6	76.0
*City Electric, Westinghouse	8,563	183.0	59.0	28.10	14.43	280.5	211.8	75.5
*B.R.T., Westinghouse	11,601	192.0	114.0	27.82	14.23	282.8	212.3	75.1
Manchester, Howden	6,383	203.0	137.0	27.40	14.30	285.8	213.7	74.8
*N. Y. Edison, Westinghouse	9,870	192.0	97.0	27.19	15.05	294.6	219.5	74.5
Zoelly, Charlottenburg	2,052	200.0	202.0	28.39	13.05	271.6	200.5	73.9
Bergmann	1,545	195.0	201.0	28.54	12.97	270.3	199.1	73.6
Brown, Boveri	3,500	162.0	133.0	28.80	13.72	278.6	203.3	72.9
*Boston Edison, Curtis	5,195	189.0	142.0	28.74	13.52	276.1	199.3	72.2
A. E. G., Moabit	3,169	185.0	215.0	29.00	12.70	268.4	192.8	71.8
Carville, Parsons	5,164	215.0	121.0	28.96	13.18	268.8	192.4	71.6
Zoelly, Augsburg Nürnberg	1,250	188.0	204.0	28.79	13.10	274.5	196.2	71.5
*New York Edison, Curtis No. 10	8,921	190.0	111.0	28.10	14.86	296.0	208.8	70.5
A. E. G., Rummelsburg	2,177	198.5	272.0	29.32	11.77	257.1	180.9	70.4
Varberg, De Laval	1,570	172.3	170.5	28.49	14.47	337.9	206.6	61.2
*Chicago Edison, Curtis	8,191	199.0	143.0	29.36	12.68	263.9	184.1	69.8

*American built turbines.

Oil Can Stand

A neat, convenient oil-can stand can be made by getting a piece of iron plate 7 inches square and ⅛ inch thick, to which four curved legs of ¼-inch flat iron are bolted. The legs are strengthened by rods running through them as shown.



OIL STAND

The cross rods are held in place by a nut on each side of each leg.

On top of the iron plate an oil tray is secured, in which the oil cans are set. This makes it convenient for keeping clean and also for moving the stand from one machine to another.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Induction Motor Repairs

By R. H. Fenkhausen

The Stator Winding

The previous articles on induction-motor repairs were confined to work which was almost purely mechanical in character; therefore no electrical knowledge or experience was necessary to make the repairs described. The repair of stator windings involves work of a distinctly electrical character, and, although it is undoubtedly possible for any mechanic of fair ability to successfully rewind the stator of an ordinary induction motor by the aid of the instructions given in this article, the work will be greatly facilitated and its quality improved if a fair knowledge of the elementary principles of induction-motor operation is possessed by the repair man. A discussion of induction-motor phenomena does not come within the scope of this article, but a careful study of the following brief description of the induction-motor field winding will aid the non-electrical worker who through necessity may be compelled to attempt repair work of this nature.

The stator core of an induction motor (often called the field) is magnetized

Fig. 1. Direct-current Field Magnet

to give alternate "north" and "south" poles exactly like a direct-current motor field magnet, but unlike the direct-current field magnet this polarity is only relative and its duration only momentary, because it is created by alternating current, which reverses the polarity of each pole 50 or 120 times per second, depending on whether a 25-cycle or a 60-cycle circuit is the source of current supply. Moreover, the bore of the field magnet is a finely notched circle instead of being broken up into a number of smooth but widely separate faces, as in the direct-current machine. In a two-phase motor there are two, and in a three-phase motor three, separate sets of polar faces or zones, each set being symmetrically spaced around the circle and alternately north and south in polarity. For all practical purposes the repair man may regard the winding of each phase as a separate

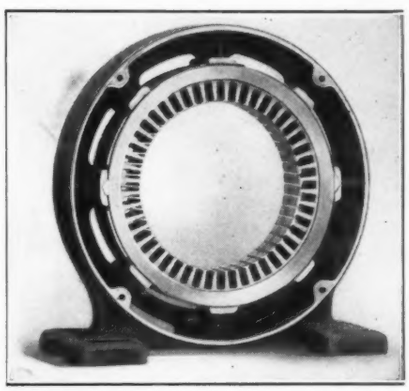


Fig. 2. Alternating-current Stator

direct-current field winding and make his connections accordingly.

On all direct-current motor field magnets, except the consequent-pole type, each magnet pole is provided with a coil containing many turns of wire, slipped over an iron core projecting inwardly from the frame, as shown in Fig. 1. The induction-motor stator, on the other hand, has no projecting poles, but consists merely of a perfectly symmetrical toothed ring built up of thin iron sheets. The slots between the teeth may be either partially closed, as shown in Fig. 2, which illustrates the stator core before the coils are in place, or else wide open, depending upon the design.

Fig. 3 shows a stator with wide open slots and with all the coils in place. It is evident from inspection of Figs. 2 and 3 that the frame and winding are perfectly symmetrical and the "poles" must be formed by proper connections between the coils.

Concentric Coils

There is one type of induction-motor stator winding which bears a marked resemblance to its direct-current prototype, namely, the "concentric" winding. A single-phase stator with this type of winding

Fig. 3. Distributed Stator Winding Secured by Lacings

is shown in Fig. 4. The polar faces are quite distinct, but are distributed over several teeth exactly as in the winding shown in Fig. 3.

Overlapping of Phases

The several series of "poles" forming separate phases on a two-phase or three-phase stator will be found to overlap one another by about one-half or one-third of the pole pitch. This is very clearly shown in Fig. 5, which illustrates a two-phase concentric winding for ten "poles."

The coils of one phase are flat loops, but the coils of the other phase are bent outward at the ends to pass under the flat coils of the first phase. It will be noted that each pole group spans its full share of the circumference of the stator bore, and the span of each group in one phase is from center to center of adjacent groups of the other phase.

This overlapping of phases is characteristic of all polyphase windings, and does not cause opposition between the poles of the different phases, as might appear at first glance. The reason for this is easily seen when the time lag of the phases is taken into consideration. Thus on a two-phase motor when the

poles of one phase are at maximum strength, the other phase is at zero, and *vice versa*. It is this action which produces the "rotating field" which forms the basic principle of induction-motor operation. Fig. 5 should be referred to when endeavoring to trace the symmetrical windings to be described further

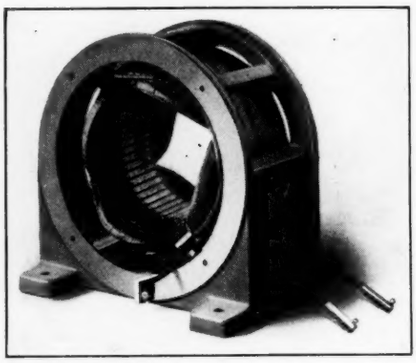


FIG. 4. SINGLE-PHASE CONCENTRIC STATOR WINDING

on, as it will aid the reader in his efforts to locate the polar faces and phases.

LOCATION OF FAULTY COILS

The first thing to do to a faulty stator is to clean it thoroughly and wash off all grease with gasolene and waste. The next thing is to raise the stator on a couple of horses, which will enable the worker to obtain a clear view of all the coils without lying on his back on the floor. Some workers have a strong tendency to assume this position, but it is not conducive to either rapid or accurate work.

The two phase windings of a two-phase machine are independent, but the

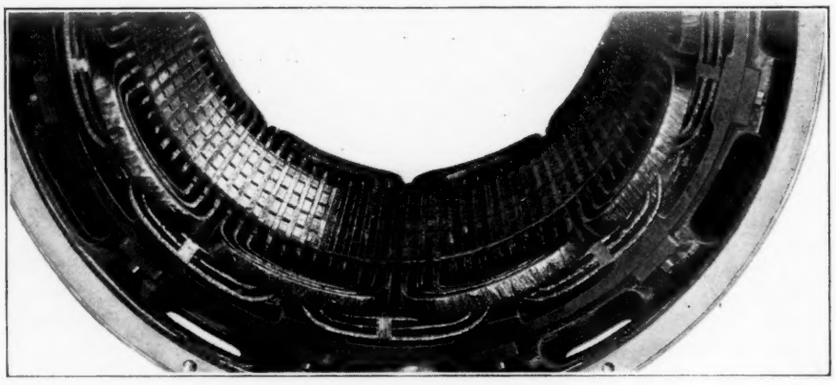


FIG. 5. TWO-PHASE CONCENTRIC STATOR WINDING

windings of three-phase machines are interconnected either "star" or "delta" fashion and it is necessary to open these connections before the winding can be tested.

In order to locate "open" places in the winding, each phase must be tested separately. Open circuits may be caused by vibration, which in time makes the wire break, or to badly soldered joints which "blow" like a fuse under heavy loads. Another cause of open circuits is grounds which clear themselves by burning off a wire, opening the winding at the same time. Tests for open circuits should preferably be made with some source of low voltage such as a vibrating bell and a few cells of dry battery. It often happens that a wire breaks and pulls apart when the motor is in service and hot. By the time the motor is stripped it will probably have cooled sufficiently to bring the ends into partial contact. If the test is made with a high voltage, it is very probable that no fault will be indicated, but if only a few volts are employed, the relatively high resistance of the imperfect connection will either prevent the bell from ringing or give only a very weak ring as compared with an unbroken circuit.

Open circuits are most liable to occur in the cross-connections between poles. These should be carefully tried by bending, as a broken wire inside the taping will be indicated by increased flexibility at the break. If no broken connections are noted a coil to coil test must be made. Much time will be saved by the use of an insulated testing handle, made out of a file handle in which has been driven a wire brad ground to a needle point at one end, as shown in Fig. 6.

One end of the test circuit may be fastened to one terminal of the motor winding and the test point thrust through the taping of each coil terminal in turn. As soon as the open circuit is indicated by no ringing of the bell, the fixed terminal of the test circuit should be moved to the other end of the motor winding and a coil to coil test made to make sure that there are no open circuits in that part of the winding. A magneto is unsuitable for this test because it will give a ring through from 10,000 to 50,000 ohms and would not detect a loose contact. By far the best testing instrument is that described in POWER of May 11, 1909, for locating broken end connections in direct-current armatures, but owing to the higher relative resistance of an induction-motor winding the bell and battery will give excellent results.

If broken end connections are found they should be repaired but if the "open" is in a coil the coil must be removed, although for temporary operation it is permissible to bridge over the faulty coil, as this is not as harmful as in the case of direct-current apparatus.

If an open circuit is found and repaired, all the other tests such as grounds, crosses, etc., should be made; a motor often is affected in several ways simultaneously. A careful series of tests may therefore save dismantling the motor a second time.

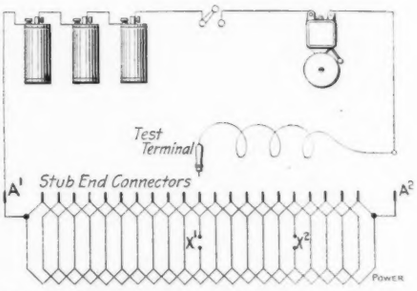


FIG. 6. APPLIANCES FOR TESTING A STATOR WINDING

GROUNDS

Weak places in the original insulation, extreme vibration, or oil spilled over the coils often lead to grounds. Excess oil soon rots the insulation and impairs its insulating quality, allowing a small current to flow from the winding to the motor frame, which carbonizes the oil and insulation until a breakdown occurs. The ground test must be made with high voltage, preferably double that of the motor. The full line voltage will, of course, do, but its use gives no assurance that any factor of safety is possessed by the insulation.

It is the writer's practice to test all 250-volt motors at 1000 volts between the frame and winding for ten minutes and 2000 volts on all 440-volt motors. This gives ample assurance that the insulation will not break down upon the occurrence of a slight increase in line voltage. If these voltages are not available, an old autotransformer out of a 2000-volt auto-starter may be rigged up as a booster, or one may be made as shown in Figs. 7 and 8, taps being taken out at the proper points for the 1000-volt test and the 110, 220 or 440 primary as indicated in Fig. 9. For 2000 volts the number of turns will be about 20,000 divided by the number of square inches in the core. This coil must be well insulated between layers and from the core.

The full test voltage must never be applied between the winding and the frame until a preliminary test in series with a bank of lamps has been made, because a violent short-circuit would result if a heavy ground existed and the resulting flash would be liable to damage a large

part of the winding. The lamps are also valuable as an indicator, as they will light up dimly even on a poor ground. Contrary to the opinion held by many electrical workers, the presence of the lamps in series does not materially lower the applied voltage at the motor because in most cases only about 5 per cent. of the

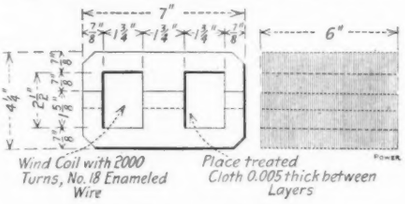


FIG. 7. TRANSFORMER DATA

voltage is across the lamps, the other 95 per cent. being available for the test. The full voltage test may be made in series with a small fuse, provided the lamp test indicated no trouble.

CROSSED PHASES

This test must be made after the open-circuit and ground tests and is made in exactly the same manner and with the same voltages as employed in the latter, with the exception that the test voltage instead of being applied between the winding and the frame is applied between the various phases. If either a ground or a cross between phases is indicated in the preliminary test, all the connections between the groups of each winding should be carefully moved away from the frame and from each other to insure that there is no trouble at these points. Crossed phases usually occur between

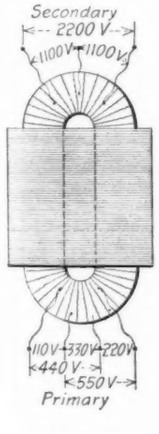


FIG. 8

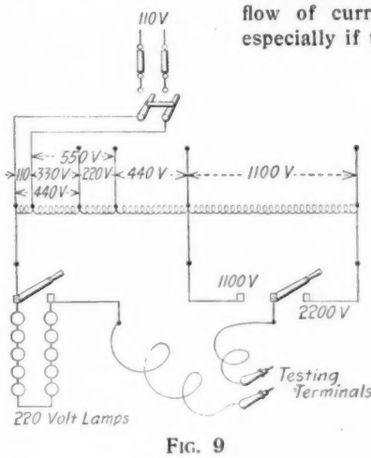


FIG. 9

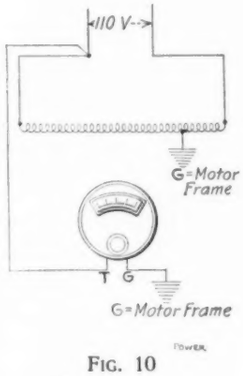


FIG. 10

the top and bottom coils in one slot and may be repaired by raising the top coil and after carefully taping the fault, inserting a new separator of micanite or treated cloth between the coils.

SHORT-CIRCUITS

Short-circuits usually result from two or more simultaneous grounds or crossed phases and therefore may disappear when such defects have been repaired. Short-circuits seldom occur except as a result of contact between end connections, in which case their presence would naturally be revealed and corrected when the end connections are raised for the ground test. Short-circuits of individual coils are of rare occurrence, and do not result in such extensive damage as on a direct-current motor. Their presence is easily detected by the partly charred condition of the insulation. A heavy overload is liable to char the entire winding so badly that the insulation between turns is destroyed, in which event the only remedy is complete rewinding of the stator.

FINDING THE FAULTY COIL

After the general nature of the fault has been determined, the exact location of the defective coil must be found. The "cut-and-try" method is most commonly used. The faulty phase is first cut in two by unsoldering the cross-connection between the central groups. The fault is then localized in one half, and that half is divided and subdivided until the exact coil is found.

A method used by the writer will locate the faulty coil exactly without opening any connections, and occasionally it is possible to detect the fault and repair it without even removing the rotor, only one end bell being removed to give access to the winding. Almost every induction-motor installation is lighted from a 110-volt single-phase circuit, and this source of current and a voltmeter with a 125- to 150-volt scale are all that one needs to locate a faulty coil accurately.

If the stator winding of the motor be connected across the 110-volt circuit, the flow of current will not be excessive, especially if the rotor is in place, and an autotransformer effect will occur, giving a potential across the terminals of each coil equal to the applied voltage divided by the number of coils per phase; each phase is tested separately, of course. This effect may be utilized as indicated in Fig. 10.

One phase of the stator winding is connected across the 110-volt lighting circuit and the voltmeter is connected between one stator terminal and the frame. It is evident that the voltage indicated on the voltmeter will bear the same relation to the line voltage that the coils bridged by the voltmeter do to the total number of coils.

Suppose, for example, there are 36 coils connected across the 110-volt circuit, and a voltage indication of 82½;

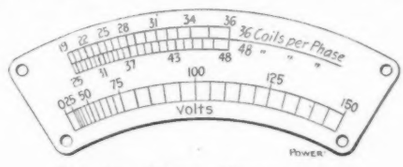


FIG. 11. EXTRA METER SCALE

110:82½::36:27, so that 27 coils are bridged by the voltmeter.

This means that the ground is between coils 27 and 28, counting from the terminal to which the voltmeter is connected, and the exact value obtained indicated a grounded end connection between groups, especially as the value is exactly three-fourths the full voltage, which would only occur between poles on a four-pole machine. As the voltage across each coil equals 3.05 volts, any indication on the voltmeter not exactly divisible by this number will indicate a ground within a coil. Owing to the more open character of the voltmeter scale above half voltage, due to the longer and more uniform division, the ungrounded voltmeter terminal should be connected to that terminal of the stator which gives the highest reading. When the reading is near half scale the mean of the readings from opposite ends should be taken.

Crossed phases are located in the same manner as grounds except that one terminal of the free phase is used instead of the ground. The voltmeter will indicate the coil (in the phase under test) which is crossed with the other phase. If desired a check test may be made with the phases interchanged, the phase which was used as a "ground" in the first test being connected across the line and the other one left free.

If much testing is to be done a special scale may be made to slip over the regular voltmeter scale, divided according to the number of coils per phase. In the writer's plant 36, 48 and 64 coils per phase cover all motors that fall below 100 horsepower, making 18, 24 and 32 divisions respectively, between the 55- and 110-volt marks on the scale. By reading the proper scale the number of the defective coil is indicated directly. As the voltage scale is not evenly divided, neither will the coil scale be, so the voltage per coil must be calculated for each scale and the values interpolated from the voltmeter scale for each coil division, as shown in Fig. 11. In using this auxiliary scale, the voltage at the terminals of the one stator winding must be maintained exactly at 110 during the test.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

The Care of Oil Engines

By John S. Leese

Starting Up

When the engine attendant gets to know his engine it will be found advisable to always leave the control levers, after shutting down, in the starting-up position. The manipulation of these soon becomes mechanical. To start the engine:

1. Light the lamp to heat the vaporizer, if one is used.
2. Oil up all around, and in cold weather see that the oil in sight-feed cups is dropping freely.
3. See that the inlet and exhaust valves do not stick in their guides, applying kerosene if they are at all sticky.
4. Engage the compression-release, if one is provided.
5. If electrical ignition is used, retard the spark; if tube ignition is used, see that the tube is hot enough for a start but not too hot or it will cause kick-backs.
6. Open the fuel feed and, if necessary, pump up the pressure to force the fuel into the vaporizer.
7. Turn the engine over by means of the flywheel or a crank, or set into action the starting gear, taking care that the engine crank is in the right position before turning on the compressed air.
8. As the engine gets up to speed, throw off the compression-release and set the ignition- and fuel-control levers at their running positions. (It will often be necessary to "starve" the engine of air at starting up, but as it gets up to speed it should be allowed as much air as possible consistent with good firing.)
9. Turn on and regulate the water supply.
10. It is often advisable to let the engine run light for a few minutes after starting up from all cold in order to let the parts get properly warmed up to their work. In fact, where ignition is by tube, it is, in most cases, sure to stop the engine if load is put on before the tube is properly heated up.

Running

To keep the engine running properly:

1. Keep the water-discharge temperature constant. In order to maintain the water at the proper temperature, which is about 140 degrees Fahrenheit, the water should pass from the engine to the drain in the open air and the temperature kept under observation by permanently setting a thermometer in the stream. On hot days and with full loads, the water in the cooling tanks, if they are used, may begin to boil. In this case it will be advisable to run off some of the water and replace it from the source of supply with cold water, making sure that the level is carried above the upper pipe opening.
2. Keep the fuel supply up to the demands of the load; if it is fed by pressure, see that the filters and pump valves do not get clogged.
3. See that lubrication is regular and sufficient.
4. In cold weather and in all winter months drain all the water out of the jackets and the entire cooling system, including radiators if these are used (not the tanks, of course), to prevent trouble from freezing.

Shutting Down

To stop the engine:

1. Throw off the load.
2. Cut off the fuel supply.
3. Switch off the ignition or turn out the lamp and open the compression-release if one is fitted.
4. Turn off all oil cups and other lubrication feeds.
5. If the engine is connected up to the exhaust pipe of another engine in such a way that the other engine could blow into its cylinder, turn the crank over into such a position that the exhaust valve will be shut. If the engine has a separate exhaust pipe, stop with the piston at the end of the outward stroke with the exhaust valve open.
6. Cut off the water supply *after the engine has cooled down.* If the water be allowed to cool down in the jacket and is, on restarting, heated up again, scale may be formed.

Cleaning Oil Engines

Always keep the outside of the engine free from oily and greasy smears. If oil is allowed to get on the concrete foundation it will do it no good and make the engine room no handsomer. If the engine is not already provided at the bottom of the bed with an oil channel, sawdust should be laid around the bedplate to soak up the oil.

The best time for cleaning the outside of the engine is immediately after or just before shutting-down time, while it is warm. Engine attendants with chilblains will have found this out for themselves in the winter time.

The amount of internal cleaning required depends largely on the type of engine, the kind of fuel and lubricating oils used and the load carried. It should cover the combustion head, piston, valves and ports, vaporizer, spark-plug points (if any), cylinder walls and oil passages. Some system is advisable in these periodical cleanings. The writer advises the following order of procedure:

1. Take out, clean and replace all filters and valves in the oil-supply system, including the pump, if any; these parts should be tightened down again ready for running again as soon as they are replaced.
2. Remove and clean the vaporizer, inlet and exhaust valves and cages, and internal ignition devices, but only the latter if they are easily removable.
3. Grind in the inlet and exhaust valves if necessary.
4. With the crank on the inner dead center and the exhaust valve in place, clean as much of the deposit and dirt out of the combustion space as possible through the inlet-cage openings. This tends to prevent the possibility of grit finding its way onto the cylinder walls.
5. Remove the piston and finish cleaning out the combustion head and cylinder walls.
6. Clean the piston, oil ways, rings, etc., seeing that the rings are free in their grooves and removing all deposit with a scraper, preferably made of copper. If all the rings are free they need not be taken off, but if they *are* removed see that the grooves receive attention. The removal and replacement of the rings should be done with great care. It is not an infrequent occurrence to find, after breaking a ring, that the stock keeper has neglected to renew his supply. Rings are best loosened by first soaking in kerosene and then, if still obstinate, they can be judiciously clouted with a piece of wood. Another good but little known dodge to ease the removal of deposit and piston rings is to stand the piston, immediately after it is taken out of the engine, in a bucket of hot water and soft soap.
7. Replace the piston, inlet valve, vaporizer and other parts, tighten up all

nuts, and turn the engine through a complete cycle in each direction to see that all is free.

8. Start up to see that the running is all right, testing the power, if necessary, with a plank or flywheel brake.

Troubles

The following are the chief and most troublesome of the irregularities in the running of an oil engine. In diagnosing complaints system must be used in order to eliminate, one by one, the possible causes of trouble:

1. Engine will not start.
2. Engine will not start, although explosions are heard.
3. Engine starts but soon stops.
4. Engine can only be started up after much cranking.
5. Engine starts up but runs spasmodically.
6. Engine stops after running some time and then refuses to run again.
7. Explosions in the inlet pipe.
8. Knocking.
9. Engine does not develop its power and will not carry its load.
10. Engine runs too fast.

Taking these faults in order, (1) refusal of the engine to start may be due to the vaporizer being either not hot enough or too hot; too little oil; excessive or insufficient air supply; electric-ignition trouble. The remedies for all these causes of failure to start are sufficiently obvious with the exception of that relating to electrical-ignition troubles. These are so numerous and varied that it is impracticable to discuss them adequately here; they would require an article to themselves.

2. If the engine will not start, although explosions are heard, this indicates that the exhaust valve requires attention. It may be that the spindle is sticking due to deposits or to being too tight in its guide, or that the valve has some dirt on its seat, preventing it from closing, or needs grinding in. Here, again, the remedies are obvious, although it may be worth while to point out that to make the valve spindle easy in its guide kerosene should be applied, *not lubricating oil*, as the application of that would tend to increase the trouble when the spindle got heated up.

3. If the engine starts but soon stops, ignoring the possibility of electrical-ignition trouble, the cause of stopping may be due to insufficient pressure on the fuel or lamp supply; faulty mixture (too little or too much air); an overload or too early application of the normal load; cooling of ignition tube; mechanical trouble, or lubrication failures. The remedies for all of these are obvious.

4. Difficulty in starting may be due to a variety of causes, such as valves sticking, valve springs being weak or broken, actuating mechanism being disarranged; too little fuel or too much air; ignition tube not hot enough. If any of these causes exist, the engine will not fire quite regularly immediately after starting but may do so after missing a few explosions. In the case of valve trouble it may be that the constant heat and stress to which the exhaust-valve spring is subjected in the course of working has destroyed its temper. In case of poor mixture the ignition tube must be heated to a temperature which will ignite poor charges. In general, the poorer the mixture the hotter the tube must be kept.

5. Irregular running is not infrequent with oil engines fitted with rotary governors working on the hit-and-miss principle. The cause can generally be traced to sticking governor parts, excessive play in the governor-mechanism joints or a badly worn pecking blade. Governors should be kept well lubricated with a rather thin oil to prevent their sticking. An occasional dismantling and cleaning with kerosene is advisable. Inertia governors are less likely to cause irregular running because they have fewer wearing parts.

Another cause of spasmodic running is irregularity in the flame of the lamp, generally due to the nipple being fouled with carbon.

6. When an engine stops and refuses to start, this may be attributable to ignition failure; fuel-supply failure; loss of compression, due to leaky valves, slack valve-cage nuts or a leaky vaporizer or igniter joint; defective lubrication, or excessive back pressure. The last mentioned trouble may be due to the gradual accumulation of water in the exhaust pipe or the muffler or to the shifting of a piece of asbestos packing in the exhaust line.

7. Explosions in the inlet pipe may be caused by the ignition of the mixture upon the opening of the inlet valve; the explosion of the vapor given off by the lubricating oil, or insufficient jacket cooling.

The first cause may be brought about by the continued or protracted burning of the previous charge until the inlet valve opens for admitting the fresh one. In this case the mixture is too weak, due either to too much fuel oil or too little air, causing slow combustion. Another cause may be the incandescence of carbonized oil or thin webs or points of metal in the combustion chamber, which ignites the fresh charge as it is drawn into the cylinder. If there is a joint in the wall of the combustion chamber and the gasket is not carefully trimmed on the inside, the fibrous ends of the asbestos may remain red hot and cause this trouble. If there are any small pockets or recesses inside the combustion chamber, where gases could continue burning more or less sheltered from the currents caused by the opening and closing of the valves, it is very often the case that these "fire pockets" ignite the incoming charge.

The respective remedies for these cases are, of course, to correct the mixture, clean and scrape the combustion chamber of dirt and projections and, where possible, plug up recesses. If the explosions are traced to the vapor given off by the lubricating oil it is time to change the oil and get a kind suitable for oil-engine work. A good-sized volume could be compiled on the requirements and properties of lubricating oils for gas engines and oil engines. Many owners seem to think that these can be interchanged with impunity, and pay a big bill for week-end engine cleaning in consequence.

8. Engine knocking. The trained engineer will soon be able to distinguish the sort of knocks due to slack bearings, premature ignitions and too violent ignitions. Premature ignitions produce a sort of dull, bumping noise and can, with little experience, be distinguished from explosions which are merely violent but properly timed. Too early firing may be occasioned by too hot a tube or too early timing, too rich a mixture, too hot a vaporizer, too much compression, insufficient cooling or an overheated charge remaining in the cylinder because of a previous misfire.

Violent explosions are in nearly all cases due to too much fuel or an excessively hot vaporizer.

While on the subject of pounding it is worthy of note that the all too common knock of a loose flywheel is the most deceptive of all. It should be corrected at once, of course. If the flywheel key be well driven in as soon as the knock is located, damage to the keyway and possibly fracture of the wheel hub may be avoided.

9. Inability of the engine to carry the load or run up to speed may be due to any one of the following causes: Faulty mixture; too early or too late ignition timing; poor compression; damaged or weak valve springs; sticking valves, or damaged valve mechanism; governor set too slow; lay-shaft gear wheel meshed wrong with crank-shaft gear.

Poor compression is the only cause requiring discussion. The best way to test the compression is with an indicator but if one is not at hand it should be noted whether oil blows past the piston, through the valve guides, etc. Grinding in the valves will often make a quite unexpected difference in the running of an engine. One method of finding leaks is by applying soapy water to the suspected parts and watching for bubbles. A leaky piston has a peculiar hiss of its own, although the writer has found that in engines with no "outside" piston ring this hissing is only heard when the leakage is excessive.

Other causes of loss of power and speed are general wear of the valve-gear

parts and back pressure in the exhaust pipe.

10. Excessive engine speed is always rectifiable by adjustment of the governor. The remarks under the heading of irregular running (trouble No. 5) apply in this case.

Dangers

By way of conclusion it may be useful to point out some of the dangers arising from the use of oil engines. The greatest is, undoubtedly, the inflammability of the fuel. All pipe and flange connections in the oil lines must be kept tight and the cover should never be left off the fuel tank. In taking down an engine it should always be seen that the ignition, if electric, be switched off. When either the valve cover or the ignition apparatus has been removed from the cylinder it is well to hold a lighted taper in the combustion space to ignite any inflammable vapor that may be lurking there. When doing this the piston should be at the end of its outward stroke and the operator's face should be kept well away from the open apertures.

Many fatal accidents have occurred through engine operators starting up by putting their feet on the flywheel spokes or gripping the rim in such a way that their arms project between the spokes. In swinging engines over the compression point the wheel should be released as soon as it is found that the crank will not go over with the one pull. Backfires have wiped out several attendants who were overpersistent in this direction.

Porcelain ignition tubes should never be closely examined when the engine is under power as the bursting of one of these, a not uncommon occurrence, generally results in the blinding of the inspector.

America's Undeveloped Peat Bogs

The great peat deposits of the United States seem destined to remain an undeveloped resource for some time to come because of ignorance of their practical value. According to Charles A. Davis, in an advance chapter on the production of peat from "Mineral Resources of the United States," for 1910, which is issued by the United States Geological Survey, noteworthy progress was made in 1910 in the production of peat fuel in other countries not only in the quantity actually marketed but also in methods of production and utilization.

In a recently perfected European gas producer it has been found that in converting peat containing a good percentage of nitrogen into gas a large amount of ammonia, greatly valued as a fertilizer, can be obtained as a byproduct. Mr. Davis quotes from a report which shows that where gas-producer plants using peat are carefully managed so great are the profits obtainable that it is often possible, while taking no credit whatever for the value of the power gas, to obtain as much as 100 per cent. profit from sulphate of ammonia alone, after making proper allowance for the cost of digging the peat, bringing it to the plant, and for labor, stores, fixed charges, etc. Indeed, with peat comparatively poor in nitrogen, it is possible in many cases to produce the gas for nothing, the cost of power being then merely that of operating the gas engines, together with capital charges on the engine plant.

Although these claims may be somewhat optimistic, says Mr. Davis, it is clear that if each ton of theoretically dry peat gasified yields from 75,000 to 90,000 cubic feet of producer gas, the heat value of which is from 125 to 135 B.t.u. per cubic foot, and also gives 200 pounds of sulphate of ammonia as a byproduct, the operation of a plant consuming 10 tons of dry peat fuel a day would produce daily a ton of the ammonia salt, worth $60.

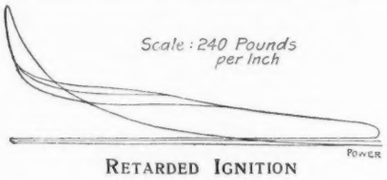
Mr. Davis believes this process is of practical application in the United States and should be investigated carefully by owners of American peat lands, many of which are very rich in nitrogen; some Government analyses show as high as 3.39 per cent. of combined nitrogen.

LETTERS

A Looped Diagram and Late Ignition

In a recent issue of Power, J. C. Parmely gave the indicator diagram shown in the figure, taken from a 100-horsepower producer-gas engine, and stated in explanation of the loop in the diagram that it "was taken with the igniter retarded as far as possible from the normal operating position, which was about 25 degrees ahead of the dead center," and that "according to the diagram, the ignition occurred slightly beyond the dead center and I think the igniter was set about 10 degrees past the dead center." The loop in the diagram, he said, "is probably due to the cooling influence of the jacket water, decreasing the volume of gas until the moment when ignition occurred."

I cannot agree with Mr. Parmely in his analysis of the diagram. Whenever the ignition of a producer-gas engine is delayed as late as this one was, 10 degrees past dead center, the engine is liable to backfire, or preignite, or both. This is due to the fact that late ignition makes the gas burn very slowly and it frequently burns so long that a flame persists in the cylinder during the suction stroke. If this flame is in a part of the cylinder close to the inlet valve, the incoming charge of gas and air is ignited before the inlet valve closes and the engine backfires with a loud report in the air-intake pipe. This cannot be detected in a diagram. If the flame is in a part of the cylinder away from the inlet valve, the ignition occurs after the inlet valve closes and burning gases are compressed instead of cold gases. This can always be detected in the diagram by the long, easy curve of compression which reaches a peak and descends along the same curve or a sharper one, and the



Retarded Ignition

expansion results in no power being generated. In this diagram the expansion line is much sharper than the compression line, making a negative loop in the diagram. The negative loop in a diagram which shows preignition is due to the influence of the cooling water when the piston is standing still. This diagram is unquestionably one showing preignition due to the delayed ignition.

C. C. Austin.

Streator, Ill.

Gasolene in the Crank Case

In the September 26 issue, Lloyd V. Beets relates some troublesome experience with gasolene getting into the crank case of a two-stroke cycle engine.

I was much interested in the article, as I have seen and operated a great many two-stroke gasolene engines on the river at this point. But I have never had any trouble similar to that described by Mr. Beets, although I have had cases where gasolene got into the crank case, due to trouble in getting an engine started, when the carbureter would overflow. But after the engine was in operation and had got warmed up the excess gasolene soon became vaporized. For a two-stroke gasolene engine to work properly and at its best economy, the gasolene should be thoroughly vaporized by the time it reaches the crank case, and the internal heat and compression should tend to dry the mixture rather than permit it to condense.

It is my opinion that the cause of the trouble could be traced to the carbureter, which might be defective or not closely enough adjusted, and therefore was feeding more gasolene than could be vaporized, or that the carbureter overflows and leaks into the crank case when the engine is not in operation. Possibly if the carbureter were more carefully adjusted it would eliminate the necessity of using the heavy cylinder oil and the economy in gasolene consumption would be very noticeable.

L. M. Johnson.

Glenfield, Penn.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Unbalanced Fields

I recently inspected a 500-kilowatt vertical Curtis turbine which vibrated so badly that bricks and mortar were loosened in the walls of the building.

My report, "field needs balancing," did not meet with the approval of those in authority and another man was put on the job.

He went through the supposedly required stunts of taking down the step blocks and guide bearing and renewing them, inspecting the middle and top bearings and transposing the governor balance weights, etc. The chief performer then declared the machine to be all right, but the operator thought otherwise, and not without reason, for the old complaint was still apparent when running with a full load.

Shortly after, a batch of experts arrived; then another, and finally the "last resort" appeared on the scene. The peculiar gyrations and acrobatic feats practised by the electors of this office suggested wireless-telegraph men. The wireless man, nervous of step, walked ten paces to the right, looking first at machine, then at the operator; five paces to the left and, as before, looking serious all the while, with an air of one who held the key to the undeveloped mysteries of the twentieth century. He climbed the ladder, and after salaaming three or more times to the governor dome, looked around the room once more and shook his head. Then he nervously jerked out a knife from his hip pocket and started down the ladder like a streak of lightning. This was too much for the natives who had been following every move with misgivings, and they bolted for the door. I intercepted the runaways and persuaded them to remain, reassuring them that all would be well, as the critical point had now been reached.

Behold! The wireless man took the knife handle in his teeth, and pressed the blade against the wheel casing, put a finger in his ear, and thus completed his observations.

In due time the verdict came: "Proceed to —— and install new top bearing; nothing serious with machine, it always has run pretty good; not much of a job," etc.

I knew that the machine did not need a new top bearing any more than a dose of castor oil. I knew that it was out of electrical balance; for every time the current was thrown on or off the field a jar could be felt on the platform, and the force of this kept pace with the strength of the field.

It was only a matter of determining which field was at fault. This was done by measuring the drop across the respective fields with a voltmeter and in this case inserting a very heavy weight diametrically opposite the field indicating the greater number of ampere turns.

This turbine has now been in operation quite a while and no complaint about the old trouble has been made.

The top bearing was left in the basement and has been forgotten.

GEORGE DAVIS.

Lowell, Mass.

Suction Lift of Pumps

The accompanying diagram shows a series of curves which provide an easy method of ascertaining the maximum suction lift that a pump is capable of dealing with at various altitudes.

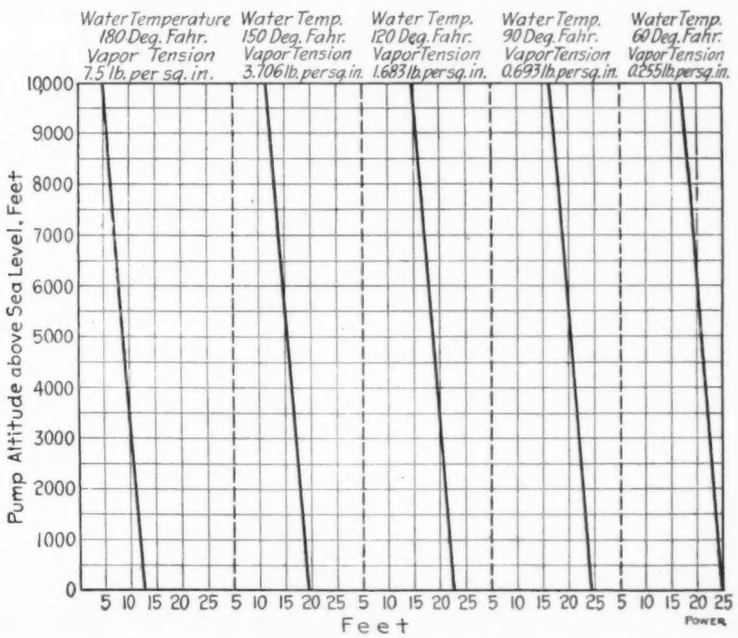

Water Temperature 180 Deg. Fahr. Vapor Tension 7.5 lb. per sq. in.
Water Temp. 150 Deg. Fahr. Vapor Tension 3.706 lb. per sq. in.
Water Temp. 120 Deg. Fahr. Vapor Tension 1.683 lb. per sq. in.
Water Temp. 90 Deg. Fahr. Vapor Tension 0.693 lb. per sq. in.
Water Temp. 60 Deg. Fahr. Vapor Tension 0.255 lb. per sq. in.
Pump Altitude above Sea Level, Feet
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
5 10 15 20 25 5 10 15 20 25 5 10 15 20 25 5 10 15 20 25 5 10 15 20 25
Feet
POWER

CHART GIVING SUCTION LIFT OF PUMPS

These curves are based on theory with suitable corrections from practice for mechanical efficiency, leakage and air pressure and have proved very useful to me in my work.

W. VINCENT TREEBY.

Essex, England.

Lap Seam Fractured

I had been at work in a New England city for several days doing external inspection and was making my last visit for the day. The boiler was of the two-plate type, having a diameter of 54 inches; the plate was $\frac{7}{16}$ inch thick. When I opened the furnace door the sound of escaping steam and water could be heard. I examined the tubes at the rear end and found them tight. I inquired of the engineer if he was aware that the boiler was leaking and he said that he was, and was going to shut down either Labor day or Thanksgiving day and try to find the leak. I immediately went to the office and explained to the manager that it would be necessary to close down at once for an examination. He informed me that the boiler would be ready the next morning.

I then applied a hydrostatic test and considerable leakage developed. As the source of the leakage could not be seen, the brick covering was removed and a fracture about 18 inches long was found

running through the rivet holes of the longitudinal seam, and directly under the rear lug on the right-hand side.

A new boiler was at once installed and when the old boiler was cut up the fracture was found to be over 36 inches long on the inside and partially through the plate. The working pressure was 80 pounds per square inch and furnished power for a three-story building.

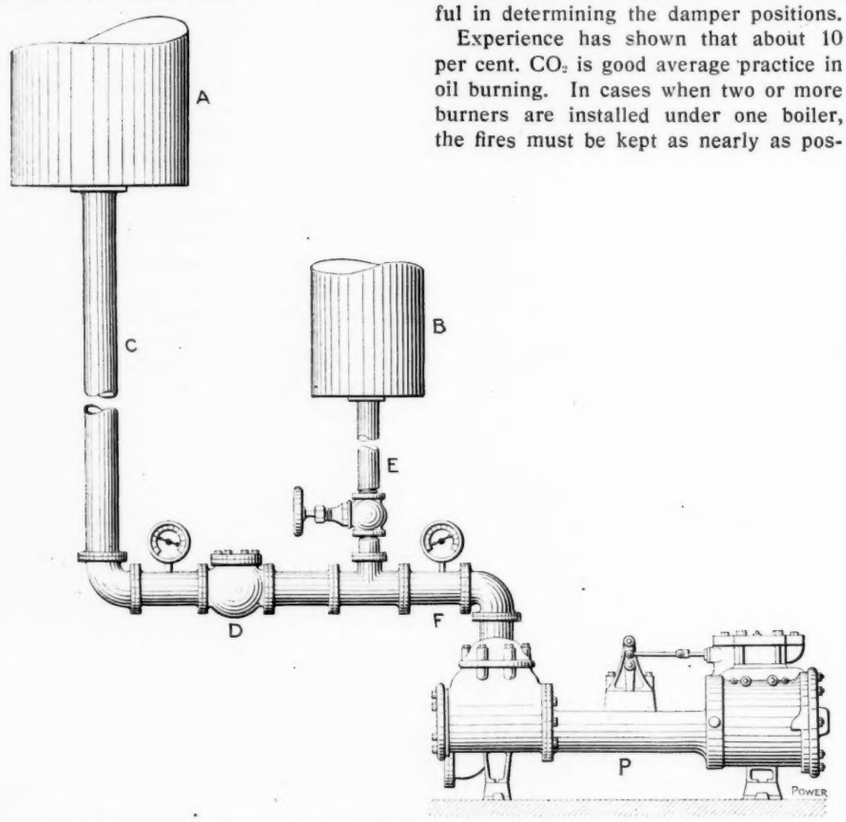
E. E. EDGETT.

Bridgeport, Conn.

Pressure in Pump Discharge Pipe

A 16 and 10 by 14-inch duplex steam pump discharges through a 6-inch pipe *C* to an open tank *A*. The pressure in the vertical pipe *C*, and against the check valve *D*, due to the hydrostatic head, is 80 pounds per square inch. Between the check valve and the pump is a 3-inch pipe *E* which leads to another open tank *B*. This pipe is fitted with a valve.

The pressure against the pump, due to the hydrostatic head in the pipe *E*, is 20 pounds per square inch.



LOCATION OF GAGES TO DETERMINE PRESSURE IN DISCHARGE PIPE

The question is, Can the pump, running at a piston speed of 100 feet per minute, discharge enough water so that the check valve *D* in the 6-inch pipe will be lifted, and water be forced into the pipe *C*, or is the 3-inch pipe *E* large enough to discharge to the tank *B* all of the water the pump can deliver? If it is, the pump cannot raise the pressure in the discharge pipe above 80 pounds per square inch, or enough more than 80 pounds to lift the check valve *D*.

I would like to hear from POWER readers on this subject.

J. F. MURPHY.

Sheboygan, Wis.

Burning Fuel Oil

When burning fuel oil the air should be admitted directly under the flame and the air opening should conform as nearly as possible to the shape of the flame. This air opening should also be subdivided into many small spaces to prevent too large a volume of air striking the flame in one spot.

After adjusting the burners so that the fires are even and are burning intensely enough to carry the steam at the desired pressure, the dampers should be adjusted until the fires are a trifle smoky or giving a light yellow haze. If the steam pressure raises, as it probably will, owing to the better combustion obtained, lower the fires a trifle and adjust the damper as before. An Orsat apparatus is most useful in determining the damper positions.

Experience has shown that about 10 per cent. CO_2 is good average practice in oil burning. In cases when two or more burners are installed under one boiler, the fires must be kept as nearly as possible of the same size and intensity. If they are not so arranged, it will not be possible to so use the dampers as to obtain the most economical draft. When the fires are found to be burning in a satisfactory manner and the dampers have been set at the correct position, nothing remains to be done but keep "hands off" and refrain from meddling. The fires should be inspected every hour or so in order to see that the burners are properly working.

When the oil burners are supplied with oil under pressure, it has been found that a ratio of 2½ or 3¼ pounds of steam to 1 pound of oil is about correct for atomizing purposes. The steam used by the burners for atomization of the oil will range from 2 to 5 per cent. of the total steam generated by the boiler, according to the type of burner used.

The burner which atomizes the oil with the least amount of steam is the more economical oil burner. It does not matter whether it be an outside- or an inside-mix burner.

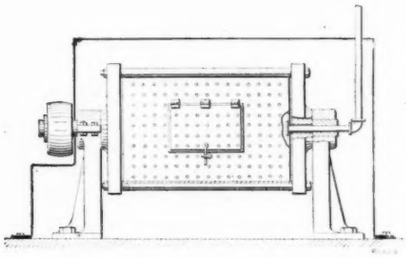
WILLIAM PATTERN.

San Antonio, Texas.

Machine for Cleaning Oily Waste

Economy in the consumption of cotton waste in engine rooms may be easily effected by the adoption of a cleaning machine built by our engineer, such as is shown in the accompanying sketch.

The material used in its construction was gathered from a nearby scrap heap of car parts and consists of two cast-iron flanges, two supports, a 5-inch pulley, four 18-inch bolts and about 7 square feet of sheet iron. The flanges were drilled to receive the four bolts and turned down on their centers to be used as axles. These flanges were old trolley stands taken from discarded cars. The supports, parts of an old exciter bed, were drilled to act as bearings and are held in place by being bolted to the floor. The sheet iron forming the can was manufactured from an old oil can and was perforated by means of a nail and hammer. This can was placed inside the long bolts, which were run through pieces of ½-inch pipe. The flanges could then be drawn up tightly to the pipe without buckling the can. A door in the can gives access to the interior. Through one flange a ½-inch pipe is loosely fitted, which carries the steam to the interior of the can for the purpose of separating the oil from the waste.



WASTE CLEANER

A speed of 1800 revolutions per minute is maintained, which is sufficient to remove oil from 3 pounds of waste in

15 minutes. A sheet-iron canopy covers the entire machine and keeps the oil from flying about.

T. T. LOGIE.

South Norwalk, Conn.

Connecting up CO_2 Recorders

Where it is necessary to use three or four CO_2 recorders on a total of 40 to 50 boilers I have found the piping arrangement herein described to be quite satisfactory. The system is cheaply installed and is easily blown out and drained.

In Fig. 1 is shown an elevation of the boilers and general layout of the piping.

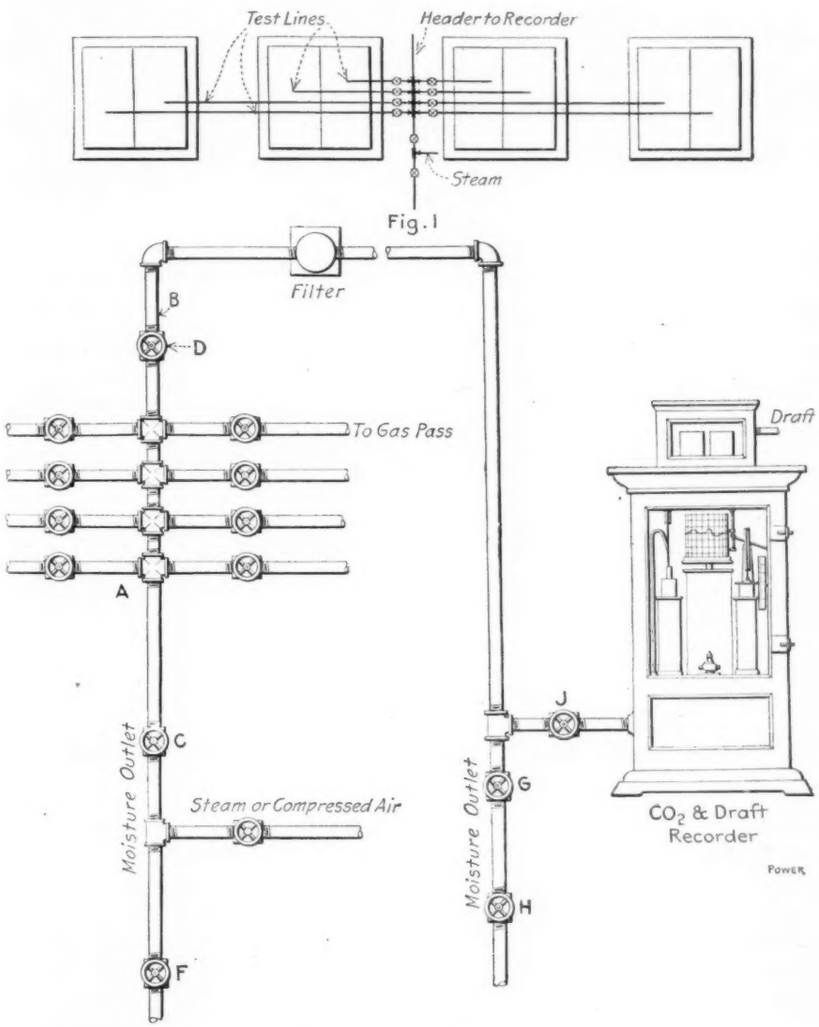


Fig. 1

FIG. 2. METHOD OF CONNECTING CO_2 RECORDER TO SEVERAL UPTAKES

A ½-inch pipe runs from the middle of the last pass in each boiler to a header that is located at the center of the system, and is easily accessible. The header then runs to the recorder, which is placed in front of the boilers where the minimum amount of piping possible will reach it, and in a cool, light place where it can be easily watched by the firemen. This line from the junction *A* contains the filter, as shown in Fig. 2. Each line connected with the junction is provided with a valve and inclosed in a box, so that, if necessary, by manipulation of the valves, the fireman may be kept in ignorance as to which boilers or boiler the machine is connected; hence he cannot be partial to certain fires and must run them all economically in order to produce a good chart.

These lines become stopped up quite frequently with soot. Therefore, a permanent steam connection (compressed air is better) is made to the lower extension of the header *B*. All valves are closed and the top of the filter is removed until valves *C* and *D* are opened; then each of the valves in the headers is opened separately and the line is given a thorough blowing out. As all the lines pitch toward the left, the moisture of condensation is drawn off every few days by opening the valve *C* until it has had time to run down in the pipe; then it is closed and the valve *F* is opened. In this way no air is allowed to enter and the steady flow of gas to the recorder is not impaired.

In like manner the condensation is drained off at the recorder by means of the extension fitted with valves *G* and *H*. This seems to be just as handy as any automatic moisture trap which would have to be disconnected when the sampling pipes were being blown out. The valve *J* is used to close and protect the machine when the pipes are being drained.

I would like to hear from any readers who have any criticisms to offer or can describe a better system.

CHARLES M. ROGERS.

Detroit, Mich.

Using the Firm's Stationery

I recently visited a steam plant in which were installed a couple of old slide-valve and a Corliss engine about four months old. The engineer in charge was a pleasant chap and in the course of our conversation related an experience he recently had. He said: "I wanted a complete indicating outfit, so I looked over POWER and saw one advertised that I liked. Here is a copy of the letter I wrote the manufacturers on our letter-head:

'Gentlemen: Please send me full particulars and quote me cash price for your indicating outfit as advertised in POWER. Include in your quotation a planimeter of reliable make. I intend to take the matter of purchase up with the firm as soon as I have read up on your instrument.

'Yours truly,

'JOHN DOE.'

"Now, friend, here is the way the company, an Eastern concern, treated my letter. They wrote to a Western machinery house to represent them in the sale of an indicator to my firm. They in turn sent a salesman who did not come near the engine room, but headed straight for the office. He met the owner with, 'Good morning; you are in the market for an indicator and I've got the very one you want.'

"The owner replied, 'No, young man, we do not need a steam-engine indicator; here is one we have had for years and it has hardly ever been used,' to which the salesman replied, 'Guess there's been a mistake somewhere.'

"That indicator in the office, friend, is an old McNaught and it has not been used much."

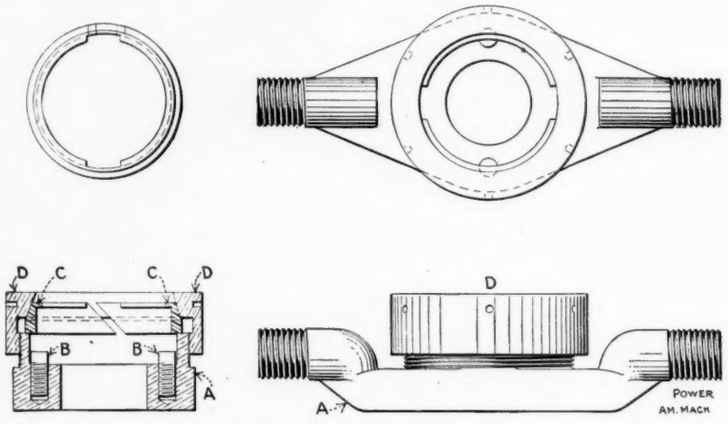
We discussed advertising from an engineer's point of view and before I came away the engineer in charge had written for another catalog on a plain sheet of paper. I have since wondered how many catalogs never come and how many manufacturers miss sales to the engineers who use the firm's stationery.

PAUL MONTAGUE.

Seattle, Wash.

Die Stock

It sometimes happens that split dies will not fit the die stock. To obviate this trouble, I decided to make a die stock to fit the dies. The accompanying illustration shows its construction. The main



IMPROVED DIE STOCK

body *A* is a brass casting and the ends are threaded for ¾-inch pipe handles. The dies are slipped into this, so that the two 7/16-inch pins *B* will catch the half-round slot on the dies and hold them in place. Above this is the steel split ring *C* and above this, a combined cap and nut.

By screwing down the cap *D* on the body *A* the split ring is compressed and the dies are brought closer together.

A lip on the ring prevents the dies from slipping out.

F. L. STEWART and H. L. KOHLBERG.
Asarco, Durango, Mexico.

Repairing a Broken Engine Casting

Some time ago the crosshead of a 9x10-inch, high-speed engine broke while running with about half a load. The engine ran in oil and there is a packing box in the position at the cylinder end of the engine-bed casting containing the oil, besides the packing box in the cylinder, leaving a space of about 6 inches between the two.

In both illustrations, *B* represents a part of the main casting of the engine bed. The packing-box casting *A* was originally put in as shown, the right-hand side being the one next to the crosshead. When the crosshead broke, part of the casting remained on the piston rod, and as the rod and piston went back it knocked the cylinder head out and broke the casting *A* and the flange *E* off of the casting *B*.

As I could not make another casting the size of *A* stay in, I filed off the broken surface at *E* as best I could and ordered the new casting sent with the outer rim unfinished so I could turn it down to fit. I could not put the new casting *A* on the inside of the casting *B*, for when the new crosshead came I found that the engine company had changed the pattern, making it so large that it came within $\frac{1}{16}$ inch of touching *A* when flush with *B*. I turned the casting down, leaving a thin flange *J*, which could not make it any thicker because the two packing boxes came too close together. The piece *F* is of wrought iron and of the same thickness as the flange.

I put on a thin gasket at *H*, replaced the two bolts *D* in the opposite way from what they originally were and clamped the flange up reasonably tight. It does not leak oil, has been running over a year and has given no trouble whatever.

If the casting *B* had been small I would have gotten a new one, but as it was very large it would have taken too much work and time to have changed it.

E. V. CHAPMAN.
Decatur, Ill.

Hot Crosshead Pin

The crosshead pin of a 2200-horsepower, vertical, cross-compound engine ran hot for almost two weeks.

Before the trouble was located the adjusting wedge was loosened and by giving the pin plenty of oil it was made to run for several days.

Then the pin was taken out and found to be badly cut. It was turned off and both brasses rebabbitted and scraped to fit the pin, after which they were replaced and a load put on the engine.

After a few hours' run it began to heat up again and get noisy. The brasses were taken up after each run, but the pin continued to run warm and wear away the babbitt. The brasses were scraped again and, when the load was put on, the trouble was still there.

During all this time the pin was getting all of the oil it needed; in fact, the oil was fed in a stream.

This pin was lubricated by a telescope oiler which consists of a pipe attached to the crosshead and hollow pin.

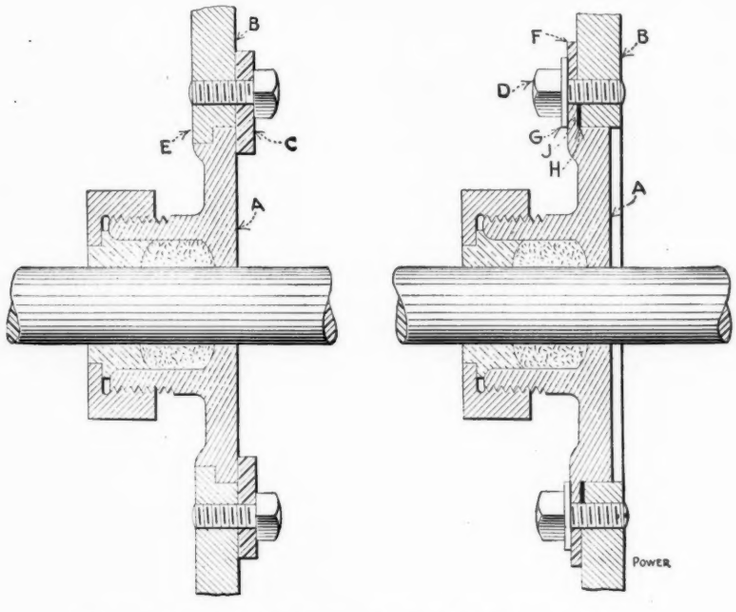
Where the stationary pipe enters the moving part on the crosshead the pipe is bushed by a brass bushing which must be a close fit.

The whole trouble was in this bushing, which had become worn so that the oil worked up around the pipe instead of going into the pin.

A new bush was made and put in, and the trouble was over.

This illustrates the importance of attending to little things about the power plant.

FREDERICK L. RAY.
Louisville, Ky.



WHERE CASTING BROKE AND HOW IT WAS REPAIRED

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Condemns License Laws

H. J. Leiper, of Philadelphia, writing in the September 12 issue of the license laws of Philadelphia, calls attention to a situation which seems almost incredible, in that men who as a class are usually considered very broad-minded, should pass, or cause to be passed, laws as despicable as the license laws of the city in question. Why an engineer should want to deprive another of the right to earn a living I cannot understand.

I would like to see the constitutionality of the Philadelphia license law tested in the courts. I do not think that the courts would uphold it because it virtually makes an American citizen living outside the city a foreigner or an alien.

I believe that the American constitution says that each State or municipality must extend equal rights to all American citizens, no matter where or in what part of the Union they may reside, and also that each State or municipality must recognize the laws of other States. If such is the case, a man who has a license to operate steam engines and boilers in one State has a right to operate or to receive a license to operate steam engines or boilers in any other State or municipality having a license law.

I understand that the Ohio, New York and Massachusetts license laws all contain a clause which provides that engineers who are licensed by marine boards or the license boards of any other State or city, may receive licenses upon applying to the proper parties. In Ohio a marine engineer must undergo the stationary examination in order to obtain a stationary license, but there is no red tape to go through and a man need not ask favors of anyone.

License laws will not increase the engineers' wages to any great extent nor will they cause a scarcity of engineers, because pay is a matter between employer and employee.

As to causing a scarcity of engineers, when a man makes up his mind to get a license he can get one all right.

I think that the only way to settle the license question is to make it a Federal license law and take the whole thing out of the hands of selfish schemers and put it under the civil service; then unscrupulous men cannot use the laws to further their own ends and every man will have an equal chance with the rest.

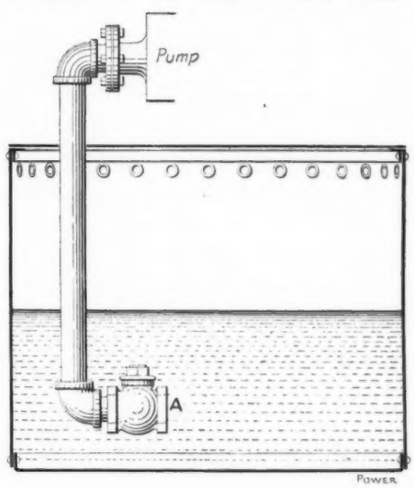
A. A. BLANCHARD.

Oak Harbor, O.

Pump Trouble

I have not had the same trouble as described in the September 19 issue by Potblyn, "Pump Doctor," but I have been up against something like it.

At this plant there is an outside-packed tandem pump drawing water from a tank, as shown in the accompanying figure; the suction pipe is 2 inches in diameter. The pipes shown at the top of the tank indicate the drip returns from steam-



ARRANGEMENT OF TANK AND SUCTION PIPE

cooking kettles; the tank is 4 feet square and is covered with a loose iron cover.

If hot water only is coming from the drips the pump will lift water no matter how slowly it is running, but if some of the drips are discharging steam the pump has to be speeded up considerably to get it to lift the water, although the temperature of the tank water remains the same as in the first case. There can be no pressure of steam in the tank above the water, as there are holes in the side where the drips enter and the cover is a very loose fit. The temperature of the water is never over 170 degrees at the check valve.

I have been thinking since reading the article above referred to, that possibly the steam above the water and in contact with the suction pipe might raise the temperature a few degrees in the pipe and thus make it a little more difficult for the pump to handle the water, so I tried an experiment. I got a piece of sectional pipe covering and placed it around the suction pipe inside the tank above the water. Then I replaced the cover, turned in a rush of steam, started the pump, and away she went as good as could be desired. Of course, I did not leave the pipe covering on; I made an outside connection for the suction near the bottom of the tank. This will remedy the trouble, and I thank Potblyn for putting the idea into my head.

J. ELLETHORN.

Toronto, Ont.

Massachusetts License Laws and Examiners

I have carefully read the letters in POWER criticizing my letter which appeared in the August 1 issue. Referring to the criticisms from Massachusetts, they are from men who have secured their first-class license, and, therefore, have no personal reason to complain with the present conditions.

The letters are more in the nature of a personal mudslinging contest than an intelligent discussion of a general subject, and they illustrate how much it is possible for some men to write without saying anything when the subject presents aspects antagonistic to their personal opinions; this latter is particularly true of Mr. Ironside's letter in the September 5 number.

He relates instances of malicious actions practised by some engineers. These things are older than the license law, and have no bearing on the subject.

I do not claim to have heard of all the protests that have been made against the Massachusetts license laws and examiners, but I have heard sufficient to occupy all the space in POWER available for discussion letters for several issues. With this thought in mind, my letter of August 1 was written in the hope of starting a campaign of clean agitation by those who have justifiable grievances, and there are plenty of them. I thought that sufficient pressure might be brought to bear to cause an official investigation into the abuse of authority practised by some of the examiners on applicants for license.

My letter was strictly general, both in word and spirit, but some of the critical

replies are strictly personal. There are some examiners who are fair-minded men; there are chief engineers who do all they can to educate and advance their assistants, even recommending them for higher positions, and there are assistant engineers and firemen who, having failed to secure the desired license, unjustly ridicule the examiner, but these cases prove the exception and not the rule. I confess myself in error in that I failed to note these exceptions in my first letter, but with these exceptions I still hold to the contents of that letter. When I made the statement that some questions made the chief engineers gaze dumfounded, I had in mind three of the best first-class engineers in the city of Springfield, Mass., and there are some others.

Mr. Smith seems to have the mistaken idea that there are no uptodate chief engineers in this part of the State, but I believe we have some who could make good even in Boston.

Mr. Smith speaks of visiting "Room 3" of the State house. An engineer other than one holding a first-class license would stand about as much chance of gaining admission to that room during a business session as he would of securing a personal interview with President Taft.

When an engineer anticipates making a visit to the examiner he usually visits other engineers, exchanging experiences and asking questions, and he visits plants where he can examine new or interesting apparatus; he also does some extra studying, but I fail to see how these things indicate that a man is being coached and crammed only for the sake of getting a license, as Mr. Lyman says in his letter.

The engineer referred to in my letter of August 1, who had 14 years' experience, was turned down because he was unfortunate in lacking the advantages of an early education, and while thoroughly capable of taking charge of and operating boilers, he was not able to design and build one.

Mr. Chadwick, in his letter of August 29, says, "that it is wrong to cease studying after a license is secured." I heartily agree with him. I subscribe to three power-plant publications, two steam and one electrical; I have a great number of books and trade catalogs, and I read and study them. I am also a member of an engineers' organization, which takes an active interest in its educational work, and the watchword among my friends and acquaintances in this business is "Learn more!"

Mr. Ironsides, in his letter of September 5, advocates making the examinations more severe. I have heard that sentiment expressed before, but it was always by first-class engineers. That the majority of these men are indifferent to the interests of their assistants and some even opposed to them is true. What stronger evidence can one ask than the very attitude these engineers have assumed toward the subject of my letter?

I have read with interest the letter on "License Agitation in Rhode Island," by Mr. McInis, in the September 5 issue, and from experience I can verify the truth of his statements regarding both the conditions and wages in no-license States. These conditions represent one unreasonable extreme, but a law which requires a man to design and erect a plant in order to secure a license to operate one represents the other unreasonable extreme.

J. A. LEVY.

Greenfield, Mass.

Direction of Compressor Rotation

In the August 10 issue it is asked if there is any reason for running an air compressor under. The answer states that there is none. If the question refers to a straight-line, steam-driven machine, I contend that running over is proper, just the same as in other steam-engine practice, as it takes power to turn the heavy flywheel and valve gear, thereby bringing the crossheads and bearings down. Running under brings them up. But in power-driven compressors it is different. They should be run under as the power begins at the main shaft; this brings the bearings and crossheads down and running over brings them up.

A. E. PETERSON.

Pocatello, Idaho.

Air and Steam Bound Pump

I read with interest Mr. Watson's article about that troublesome pump at the Maddern mills. I had a similar experience with a pump in a plant where I was employed. The heater was connected up in a manner similar to Mr. Clark's heater, excepting that there was no float valve to keep the water level, which was controlled by a globe valve in the cold-water supply.

The cold-water pipe entered the heater at the same end as the bleeder exhaust from the engine. Back pressure was carried on the engine for the heating system and it quite naturally caused some steam to go to the heater and heat the feed water to 212 degrees.

The feed pump would run smoothly just so long as no cold water was turned into the heater; but, as soon as cold water was turned on, the pump would begin to pound and show signs of getting air or steam bound.

I finally decided, as "Pump Doctor" did, that the cold water caused a vapor in the pump-supply pipe. I ran a vent pipe from the top of the heater through the roof of the boiler room, which stopped the trouble.

A. STALEY.

Joliet, Ill.

Failure of Mixed Pressure Turbine Installation

In the issue of September 26 is an article entitled "Failure of Mixed Pressure Turbine Installation," by C. A. Tupper, which is misleading.

In the article it is stated that the turbine manufacturers were very much interested in this particular plant and that after an apparently careful examination of the operating conditions they all but one refused to put in a proposal, stating that the scheme was not commercially feasible. It is very hard to understand how such a statement could be made when referring to two years back, it is noted that a large number of installations were in successful commercial operation, none of which was essentially different from the plant mentioned in Mr. Tupper's article.

In the installation referred to some 10,000 pounds of exhaust steam per hour are wasted and it is difficult to understand how it can be said that this available amount of exhaust energy had better be abandoned.

The hoisting engine mentioned has an exhaust of "cyclonic violence." This is no way objectionable as regards the further use of steam in a constantly running engine if proper means to handle this exhaust be employed. It is quite true that the hoist shuts down for periods as long as half an hour, an hour, or even more. This can readily be taken care of by the use of a suitable mixed-flow turbine, which allows the use of some high-pressure steam when the low-pressure steam is deficient or runs entirely on boiler steam when the low-pressure steam supply is exhausted. Mixed-pressure turbines can be made to have, when running on high-pressure steam, as good a steam economy as straight high-pressure turbines. This is a question of design.

Mr. Tupper's article implies that steam regenerators cannot equalize the exhaust from powerful hoisting engines without imposing on the hoisting engines undue back pressure (in the case referred to, 10 pounds gage).

There are in operation some 500 or 600 regenerators, some of which have been in operation for the last seven or eight years, which handle intermittent fluxes of steam compared to which the exhaust of the engine referred to is but a trifle. If 5 pounds variation of pressure be allowed in a properly designed regenerator at the plant referred to (which is far in excess of steam-regenerator practice), a steam turbine could use the exhaust steam discharged by the hoisting engine without any appreciable amount being wasted.

The failure of the plant (which was predicted by the writer) is entirely due to the poor design of the steam regenerator.

The regenerator used at the mines referred to was described and discussed in POWER of November 8, 1910, by C. H. Smoot, and the results of its operation foreseen. The method of heat absorption in the device employed is the same as in the Rateau regenerators; that is to say, is obtained by mixing water and steam, the flow of steam in both cases being used to promote circulation of water, but the design of the apparatus is such that instead of using a light pressure to displace large masses of water, a considerable pressure is employed to displace small amounts of water. For the extremely large zone of condensation of the Rateau machine is substituted a restricted zone, which is so disposed as to oblige the steam to force its way through a head of water some 7 feet in hight.

The writer agrees with Mr. Tupper that under the circumstances the low-pressure plant not only "would appear" but has resulted in an actual loss. It is somewhat late to express any doubt as to the commercial value of the use of mixed-flow turbine plants operating on the exhaust of hoisting engines.

There are quite a number of mines abroad where the mixed-pressure turbines installed as stated drive electric generators, high-pressure centrifugal compressors or pumps, and on which the mines rely exclusively for their operation. These plants have made large savings for their owners.

In this country, mine owners are rapidly commencing to realize that it is bad policy to waste the exhaust steam from their hoisting engines; several plants are now in operation or ready to operate. In such installations the use of steam regenerators having large heat-storage capacity and so designed as to be able to absorb excess steam practically instantaneously must be provided.

The use of mixed-pressure turbines having high efficiencies when running on boiler steam is necessary when complete shutdowns of the hoisting engines are to be expected. Straight low-pressure turbines cannot be recommended in any plant where the turbine is to run on boiler steam expanded through reducing valves for any length of time. In other words, 40 pounds of steam never should be used to produce a kilowatt-hour when 20 pounds can do as much.

I do not agree with the statement that "the facts were soon spread abroad and have caused unwarranted injury to the legitimate claims of low-pressure turbines in the extensive district affected, for the reason that the power-using public does not take into account the circumstances that this unit was installed in a place for which it was not adapted." The facts well spread abroad are that the plant was entirely experimental for the people who undertook to place it in operation, and that no steam regenerator of the design used was ever built before. The mine owners were fully informed of all this, and the writer was told that a bond had been required for protection against patent suits and the performance of the plant. The plant failed, due entirely to the regenerator, which is so designed that the rate of steam absorption is inadequate.

The writer's contention can readily be disproved, if wrong, as engineers of great ability have tested the regenerator carefully. The publication of any one of these tests will, I think, realize the desire of Mr. Tupper, which is to have the mining engineers fully informed.

On the other hand, as regards the advisability of such installations, I refer to all the plants my company has placed in operation in this country, some of which handle the exhaust steam of reversing mill engines at the rate of over 350,000 pounds per hour.

L. BATTU,
President, Rateau Steam Regenerator Company.
New York City.

Loose Crank Pin

In the September 5 issue, Mr. Fitts cannot understand why the loose crank pin caused the centrifugal oiler to unscrew from the pin when the pin turns in the disk. He does not state whether the engine is a right-hand or left-hand, but that the pin turns to the left, or

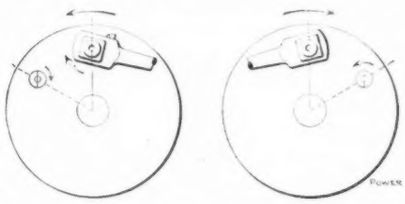


FIG. 1. RIGHT-HAND ENGINE FIG. 2. LEFT-HAND ENGINE

counterclockwise, and at the same time the oiler unscrews.

I believe there is some mistake here, assuming it to be a right-hand engine and running over as he says it does. When the crank-pin brasses grip the pin it turns to the right in the disk, or clockwise, as shown in Fig. 1. This would cause the oiler to unscrew if it had a right-hand thread.

If he has a left-hand engine the pin turns to the left, or counterclockwise, as shown in Fig. 2. As he says it does, this would cause the right-hand threaded oiler to screw in tighter as the pin turns to the left, while in the first case the pin turns to the right with regard to the oiler.

I believe his mistake is in assuming the pin to turn to the left when it actually does turn to the right and that he has a right-hand engine. It would be interesting to know if this is the case.

J. C. HAWKINS.
Hyattsville, Md.

Why Central Station Catches Isolated Plant Business

I note in your September 26 issue, page 477, an article entitled, "Why Central Stations Catch Isolated-plant Business," by H. D. Jackson. There is much truth in what Mr. Jackson sets forth as to the reasons for central stations getting the business which he claims is justly due to be handled by the isolated plant. The central stations do have solicitors who are expert engineers and know rather intimately the costs of power both as produced by the central station and by the isolated plant, but in suggesting that these solicitors in general deliberately mislead the prospective customer as to his costs from the use of the isolated plant I think he is wrong. Not all solicitors are paragons and some of them make misrepresentations. I do say, however, that the solicitors of the central stations grade up in integrity and in ability with men in any branch of endeavor, and that it is not the policy of the central station (broadly speaking) to get business on any basis except that of strict integrity.

In soliciting the business of the isolated plant frequently the operator or owner has not taken into account all of the expenses and it is a perfectly legitimate practice to call attention to these overlooked items. Frequently the isolated plant could make changes and effect economies which in themselves would reduce costs to the same level of service purchased from the central station, but I am unable to see that it is the solicitor's duty to teach the isolated-plant man how to run his business nor that it is sharp practice to sell his goods and thereby save the consumer on his power bill. This same thing is done in all lines of business, and the salesman who shows how to save money by using his firm's product (although the use of this product may not be entirely responsible for the saving) is a benefactor.

One fact in the central-station proposition which must not be overlooked is that unless they make good on the savings effected the business will be lost. That they are not losing all of this business shows that they are not failing to make good.

If, however, the engineer in charge of the isolated plant were on the job he could frequently match the costs of central-station service, but that he is not alive and allows the central station to underbid the costs of isolated-plant operation is certainly no fault of the central station. Then, too, there are cases of coal cartage, small-size installation and other features incident to the isolated plant which make it inevitable that service can be purchased cheaper than it could possibly be furnished by the isolated plant.

To the extent that they induce engineers of isolated plants to keep definite records and ascertain not only what they are doing, but enable them to successfully reduce their costs, articles as that above referred to will be productive of great good. But it does not appear to the writer that it is necessary to impute any dishonesty to the central-station solicitor in order to make out a case.

Whether service will be supplied by central station or isolated plant will ultimately be decided by the economics of the case rather than by any appeal to prejudice or sympathy.

R. L. ELLIS.

Selma, Ala.

Sand for Hot Boxes

In the August 29 issue of POWER appeared an editorial, "Sand for Hot Boxes," in which the statement is made that on many ocean steamers a box of sand is a part of the engineer's emergency outfit. I have been a marine engineer for the past 30 years and I have never seen a box of sand on shipboard and I hope that I never shall. When an engineer is running marine journals the only sand he needs should be in his own makeup.

I would like to hear from engineers who have used sand and in what class of steam vessels.

I also noticed in a later issue an article on refrigeration which stated that in order to get the best results the condenser and suction pressure must be carried as low as possible.

I get the best results by carrying my condenser pressure as low and my suction just as high as I can and get the temperature required; the higher the suction pressure the more ammonia the machine will handle and less power is used to do the work.

FRANK H. CORDNER.

Niantic, R. I.

Value of CO_2 Recorder

It is not my intention to criticize the previous writers on the above subject, but when a man of E. A. Uehling's capacity makes two conflicting statements, as he did in the June 13 issue, where he says, "in all cases high or low CO_2 means high or low efficiency," and again in the issue of August 15, where he says, "since CO_2 by itself is not claimed to be, and in the nature of things cannot be, a measure of efficiency," etc., it seems to me as though Mr. Uehling should write and explain clearly which of his two statements he is ready to back up and why.

That the CO_2 recorder is of any value in measuring furnace efficiency is a question to which no definite answer has as yet been given in the articles that have appeared in POWER.

I agree with Mr. Uehling that "in all cases high or low CO_2 means high or low efficiency," for the higher the percentage of CO_2 the greater the number of available heat units to be transferred to the water within the boiler. If this tends to efficiency then a high percentage of CO_2 means a high efficiency. If in all cases high or low CO_2 means high or low efficiency, why is not the CO_2 recorder of any value in measuring furnace efficiency?

A combined CO_2 and draft recorder, properly installed to draw an average sample from the gases at a point where they are leaving the heating surface of the boiler, will certainly be of value in measuring furnace efficiency.

For the sample I would use a ½-inch pipe, capped at the end inserted into the path of the gases and having ⅛-inch holes drilled about 3 inches apart, the pipe being extended fully across the path of the gases. As the percentage of CO_2 is to a great extent influenced by the draft, it demands that a draft recorder be installed with the CO_2 recorder. A combination apparatus if properly cared for will show on the chart the percentage of perfect combustion, and will show the draft employed at the time the CO_2 was recorded; a study of the chart will show just in what position to set the damper to obtain a draft through the bed of fuel that will give the greatest percentage of CO_2.

It is necessary to know whether enough excess air is being heated to keep a duplicate furnace running to its full capacity. If the percentage of CO_2 is as low as 7 per cent., enough excess air is being heated to keep a duplicate plant running, and between 25 and 30 per cent. of the heat units is lost in heating air from atmospheric temperature to the temperature of the leaving flue gases.

In locating these troubles and finding their remedies the CO_2 recorder is practically useless, as it is limited to CO_2, while it would be necessary to determine O and CO. The CO_2 recorder is too slow for this work; it makes an analysis only once every four or five minutes, when it may be necessary to analyze a sample every minute.

To measure and locate air leakage two gas samples must be taken from two different points in the setttng simultaneously; then make a separate analysis. Here again the CO_2 recorder would be useless as it is not practical to connect it anywhere but in the breeching at the point where the gases leave the heating surface of the boiler.

In working for higher efficiency with the gas-analysis instrument every observed furnace condition must be noted at the time each CO_2 determination is made; every such condition has its cause for being so and any change in that condition will effect an increase or decrease in the percentage of CO_2 or the efficiency. If, for instance, there is a bare spot in the fire about 2 feet square, take a sample of gas, analyze it. Then cover the spot with fuel and analyze another sample, and invariably a higher CO_2 reading from the last than from the first sample will be obtained. By applying the draft gage, flue-gas thermometer and flue-gas analysis instrument diligently to the furnaces the indicator on the CO_2 recorder will point to the percentage of CO_2 that means highest efficiency, and the coal bill will be reduced. Then make CO_2 recorder keep watch over the improved furnace conditions that they may not gradually get back to the old point of inefficiency.

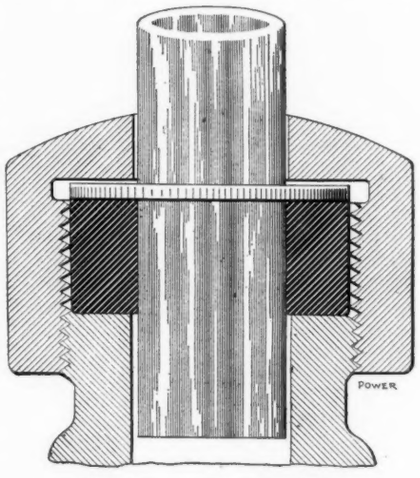
R. S. WILHELM.

Indianapolis, Ind.

Gage Glasses

In the September 19 issue, Mr. Bond asks me to explain more fully about putting in gage-glass washers.

The accompanying sketch will do that better than words. The washer is for the purpose of preventing the rubber gasket sticking to the nut. If the washer



WASHER IN PACKING NUT

were placed below the gasket, the rubber would stick to the nut and it could not be tightened without danger of turning the glass in the opposite stuffing nut, which would tend to break the gage glass.

GEORGE R. WILLIAMS.

Findlay, O.

Noiseless Corliss Valve Gear

My method of lessening the noise of the valve gear being different from either Mr. McGahey's or Mr. Mistele's in the August 15 and September 19 issues, respectively, I will give it herewith.

Noting where the steel tailpiece came in contact with the knockoff-cam collar, I drilled a ⅜-inch hole ⅜ inch deep at that point and inserted a plug, which has been renewed but once in 15 months.

W. A. WATSON.

Marion, O.

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POWER

Pipe Flanges

The question of suitable flanges for steam piping is of the utmost importance. In a recent editorial attention was called to the fact that of all parts of the pipe line the fittings must be the strongest. This is necessary on account of the strains thrown upon them by the expansion and contraction of the piping.

For pressures of 250 pounds or more, extra-heavy wrought-steel flanges welded on make the best construction, provided the weld is properly made so that the flange becomes a part of the pipe itself. One is never certain, however, that this has been done, and care must be used in the selection of this process for this reason. There are also several other methods of applying flanges that have been quite satisfactory.

For sizes up to and including three and a half inches it is customary to use threaded flanges and screw them upon the pipe. This is also a common practice for larger sizes when the pressure does not exceed one hundred and twenty-five pounds. If the steam is not superheated, cast-iron flanges will answer very well up to two hundred and fifty pounds, although for the higher pressures the greater safety resulting from the use of ferrosteel or forged steel no doubt fully warrants the slightly increased cost of the latter materials.

In order to insure a good job of piping, it is imperative that the flanges be faced off after they have been put on the pipe so that they will be true with the pipe and have a good contact when put together. A cut should be taken the entire width of the flange and, if it is screwed on, the end of the pipe should protude enough to allow its being faced off flush with the face of the flange. This will then give the gasket a bearing upon the end of the pipe as well as on the flange.

Nearly all manufacturers specify in their catalogs that companion flanges will be furnished with smooth faces unless otherwise specified. Whether or not this means that they recommend plain-faced flanges as preferable to all others is not stated.

In this particular there are several types of flanges, such as the above mentioned, namely: plain, male and female, tongue and groove, raised, and flanges with a calking recess. In some plants the plain or smooth face is preferred for all pressures and it is universally used for low-pressure work because of the ease with which repairs can be made. Others use exclusively a flange having a raised face about one-thirty-second inch high, extending the full width inside the bolt holes. This projection is smooth tool finished and is particularly adaptable when using metallic gaskets. Probably the safest kind is the male and female which practically eliminates all danger from gaskets blowing out. This type is also more commonly used under high pressures than any of the others.

Multiplicity of Heads

Experience has demonstrated that concentration is one of the remedies for useless waste. Years ago the scheme of appointing heads over the several departments was adopted. This has always been successful as the heads of concerns are not bothered with details, but can turn their attention to outlining the general policy.

As an illustration, many large manufacturing concerns have several separate steam plants, each in charge of a running engineer responsible to a chief engineer, who makes his report to the agent of the works. Holding the several acting engineers responsible to a chief engineer is productive of economic operation. Nothing demoralizes the engine-room force so thoroughly as to have several heads over them; the men are then responsible to no one in particular.

In a certain manufacturing company there are seven separate steam plants. Each has its chief engineer who has complete control of his plant and is responsible to no particular head. Each one does his work to suit himself, and if he finds a method of reducing operating expenses he keeps it to himself rather than inform his associates; as a result the company suffers a loss.

What is everybody's business is nobody's business, and this truism is evident in the case cited. If a chief engineer were in charge of all of these steam plants the improved methods adopted in one would be applied to all and the company would be benefited. Further, each acting chief would try to make a good showing with the chief, and, although there might be rivalry, it would, on the whole, be beneficial.

Jealousy among engineers is harmful. It causes them to become selfish and self-centered and, what is worse, they lose

sight of the fact that they are supposed to be working for the best interests of the company. When there is no central head there is no restraining influence over jealous subordinates and the work is not systematically performed.

The chief engineers of large establishments are usually men who have executive ability as well as engineering experience. They know how to prevent discord, and they aim to promote such good will among the men that they will all work together for the best interests of their company.

Purchase Coal by Specification

Someone has said that the intelligent farmer shows better business judgment in the purchase of fertilizer than most manufacturers in buying coal, for the farmer insists upon a chemical analysis of his proposed purchase. Until recently coal has been bought in a most haphazard manner, on the recommendation of the dealer, on the reputation of the mine or perhaps on the supposition that the mining district from which it came could furnish only coal of superior quality. Under this system or lack of it, if the purchaser found fault he was usually assured that the quality of the coal was equal to that of former days or years for it came from the same mine and must be good because the mine had established a reputation which must be maintained. Purchasers did not take advantage of the competition which usually exists when a number of dealers are asked to bid on the price of a year's supply, for they were shy of contractors and dealers whom they did not know, because, though each might claim that his coal was as good as the best, there was no standard for settlement if the fuel delivered proved unsatisfactory.

Millions of tons of fuel are bought every year upon terms that would be considered ridiculous if the commodity transferred were scrap iron or paving stones. Where the products of mines other than coal are sold in open market or by private sale the price paid is based on chemical analysis. This is true of coal to a limited degree only but the number of yearly contracts for coal based on its heat value is rapidly increasing, for both dealer and consumer are beginning to realize the advantage of having a definite understanding regarding the quality of the fuel delivered just as would be the case if the contract was for hydraulic cement or oak-tanned sole leather.

When a dealer is asked to specify the quality of coal he proposes to furnish he is placed on equality with all other dealers and strict competition decides the question of what coal shall be used. Local conditions often cause a variation in the quality of coal from a certain mine; more care in rejecting slate is exercised at one time than another. The mining companies are responsible for this, but the sale of the output of the mine on the basis of its quality will stimulate the mine owner to furnish the best available product. With the utmost care, however, there will be some variation in the quality and no contract will be satisfactory to either dealer or consumer that fails to recognize and make provision in an equitable degree for this variation. A contract which fixes the price for a certain heat-unit content with deductions for inferior and bonuses for superior quality will seldom fail to satisfy all concerned in the transaction.

Coal is burned for the purpose of utilizing the heat content. It is the combustible that is wanted and it is that portion of the combustible that can be burned in the furnace that should be measured and for which payment should be made. That fuel which will give the most heat, all things considered, for each dollar spent, is the fuel that will produce a horsepower-hour at the lowest price. With equitable deductions for the handling of extra bulk of coal and ash with a low fusing temperature, making clinkers which complicate the firing problem, and with bonuses on excess of heat content above contract specifications and a nonclinkering ash, an entirely satisfactory arrangement for both parties should exist.

If coal is purchased under such specifications, the buyer gets what he buys and pays only for what he gets.

Indicate, Register and Record

Does a steam gage indicate or register or record the pressure in a boiler? With regard to the gage it would be perhaps most natural to say that it "shows" or "indicates," but we say of a thermometer that it "registers" such and such a temperature, when it does nothing more than to indicate or show it, and there is warrant both in the dictionary and in usage for saying that the clock "records" the passing hours.

Does an indicator indicate or register or record what goes on in the cylinder during the stroke? If it does all three, in what does each consist?

By usage and common understanding the word indicate, as applied to measuring apparatus, is restricted to the momentary indication or showing of the apparatus, without any reference to the marking down, registration or preservation of any record of this indication for future reference or for comparison with other indications. The hight of the pencil of a steam-engine indicator "indicates" the pressure beneath its piston at the instant. By the marks which it makes upon the paper the pencil "records" the pressure at each point of the stroke. The record may "indicate" that the valves are late or early, etc.

To "record" has come quite generally to involve the making of a permanent record. Thus we have the recording pressure gage which draws a record or diagram showing the pressure existing at any time of the day. This gage properly "records." The ordinary gage only indicates; but how frequently one reads that "at the time of the explosion the steam gage 'recorded' one hundred pounds," etc. In CO_2 apparatus we have the Orsat which enables us to determine the CO_2 in a given sample, the instruments of the Econometer class, such as the Hays analyzer, which have an index "indicating" the percentage of CO_2 passing at the moment, and those that, like the Uehling, Sarco, etc., "record" these percentages upon a diagram which may be preserved for reference and comparison.

The word of most uncertain use is register. Although its derivation (*re* = back, *gero* = to carry, whence the Latin *regesta* = records) and our use of it in politics, business and law all imply a marking down, a record, we have also the frequent use of it recognized by all the dictionaries, to signify simply indication, as when the thermometer "registers" 90 in the shade, the steam gage "registers" 100 pounds, etc.

There is another class of measuring apparatus which does more than indicate but does not record. The counter, for instance, which registers the strokes of a pumping engine, tells how many strokes the engine has made in a given time but does not furnish a record of how the making of these strokes was distributed. A gas meter registers the number of cubic feet of gas which pass through it, but does not tell whether the use was uniform or variable nor what the rate of flow was at a given time. One would hardly allude to the counter as a meter, nor to the meter as a counter, but both do register.

On the face of a Venturi water meter are three dials illustrating the three operations referred to. First, there is a hand or index which points to the number of gallons or cubic feet which are flowing at that instant through the meter per unit of time. It *indicates* the momentary rate of flow. Then there is a counter which *registers* the total number of gallons or of cubic feet which have passed through the meter. Then there is a pen which *records* upon a chart rotated by clockwork the rate of flow for each instant of the day.

Would it not be well for engineers and writers upon engineering subjects to agree upon some such restriction of the application of these loosely employed terms?

It is reported that a coalfield having nearly 100,000,000 tons has recently been discovered in Leinster, Ireland, and that its quality is equal to that of the best Welsh steam coal.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Horsepower of Engine

An indicator pencil has a vertical movement of one inch, which represents a pressure of 60 pounds. The length of the stroke of the engine is 20 inches; it makes 90 revolutions per minute, and the piston is 10 inches in diameter; what is the horsepower developed?

J. P. L.

If the average hight of the pencil movement was 1 inch, it would represent a mean effective pressure on the piston of 60 pounds per square inch. A common formula for the horsepower of a steam engine is

$$\frac{PAS}{33{,}000} = \textit{horsepower}$$

in which

P = Mean effective pressure against the piston;

A = Area of the piston in square inches;

S = Speed of the piston travel in feet per minute.

Substituting the known values in the equation and solving,

$$\frac{60 \times 78.54 \times 300}{33{,}000} = 42.84 \textit{ horsepower}$$

Cutoff and Number of Expansions

If the cutoff on the high-pressure cylinder of a compound engine occurs at quarter stroke and that on the low at one-third, how many expansions will there be in both cylinders?

C. N. E.

The number of expansions in a compound engine is the product of the number of expansions in the high-pressure cylinder and the cylinder ratio. With 4 expansions in the high-pressure cylinder and a cylinder ratio of 4—that is, the low-pressure cylinder having 4 times the volume of the high—the number of expansions would be 16. The cutoff on the low-pressure cylinder does not affect the number of expansions but is used to distribute the load between the cylinders.

Centigrade and Fahrenheit Thermometer Scale

What is the difference between Fahrenheit and Centigrade thermometers?

C. F. S.

On the Fahrenheit scale the space between the freezing and the boiling points is divided into 180 parts or degrees, and on the Centigrade into 100. Therefore, a degree Centigrade is 9/5 of a degree Fahrenheit. To convert Centigrade readings into Fahrenheit, multiply the reading by 9/5 and add 32 because the zero of the Centigrade is equivalent to 32 Fahrenheit. To convert Fahrenheit into Centigrade, subtract 32 from the reading and multiply the remainder by 5/9.

Hight of Pump Lift

If 80 pounds steam pressure in a pump cylinder will force water to a hight of 150 feet, how high will it be forced by pressures of 90 and 100 pounds respectively?

H. P. L.

Neglecting the pump friction which would be proportionally less for the higher pressure, 90 pounds pressure would raise the water

$$\frac{90 \times 150}{80} = 168.75 \textit{ feet}$$

and 100 pounds

$$\frac{100 \times 150}{80} = 198.75 \textit{ feet}$$

Steam and Water Temperature

If 25 pounds of steam at atmospheric pressure were mixed in a barrel with 100 pounds of water at the boiling point, how much would the temperature of the water be raised?

S. W. T.

Steam at atmospheric pressure having the same temperature as the water could not give up any of its heat and would rise to the top of the water and pass off as steam.

Capacity of Centrifugal Pumps

How many cubic feet of water will be discharged per minute through a 9-inch pipe by a centrifugal pump 36 inches in diameter running 300 revolutions per minute and against a head of 90 feet?

C. P. C.

The head against which a centrifugal pump will discharge depends on the linear velocity of the tips of the blades. At 300 revolutions per minute the tips of the blades of a 36-inch impeller would have a velocity of 47 feet per second and with an efficiency of 100 per cent. would impart this velocity to the water, which is equivalent to the velocity that would be acquired by a body falling through a hight of approximately 34 feet. To rise to any hight the water must leave the pump with a velocity equal to that which would be acquired by falling through the same hight; therefore a 36-inch impeller running at 300 revolutions per minute would raise water only to a hight of 34 feet. To raise it to 90 feet the velocity would have to be 76 feet per second, which would require 400 revolutions per minute and an efficiency of 100 per cent.

Changing Ice Machines

If while running one of two ammonia compressors it is desired to change over to the other machine, how should it be done?

C. I. M.

Warm the steam cylinder in the usual way and when ready open the stop valves in both the suction and discharge pipes. Bring the machine slowly up to speed and reduce the speed on the other; with it running slowly, close the suction-pipe stop valve and then the one on the discharge pipe. A compressor should not be either started or stopped with the discharge-pipe stop valve closed.

Factor of Evaporation

What is the factor of evaporation?

W. F. E.

The factor of evaporation is the number by which the observed evaporation is multiplied in order to convert it to the equivalent of evaporation of feed water at 212 degrees into steam at atmospheric pressure. To evaporate 1 pound of water under these conditions requires the expenditure of 970.4 heat units. For any other conditions the factor may be found by subtracting the total heat above 32 degrees in 1 pound of feed water from the total heat in 1 pound of the steam and dividing the remainder by 970.4. With feed water at 185 degrees made into steam of 150 pounds pressure the factor of evaporation is

$$\frac{1195 - 152.89}{970.4} = 1.073$$

If 9 pounds of water were evaporated per pound of fuel under the conditions given, the equivalent evaporation from and at 212 would be

$$9 \times 1.073 = 9.657 \textit{ pounds}$$

Heating and Ventilation

Considered as power plant problems. Layout and operation of systems and apparatus

Heating an Addition to a Factory

By W. H. Wakeman

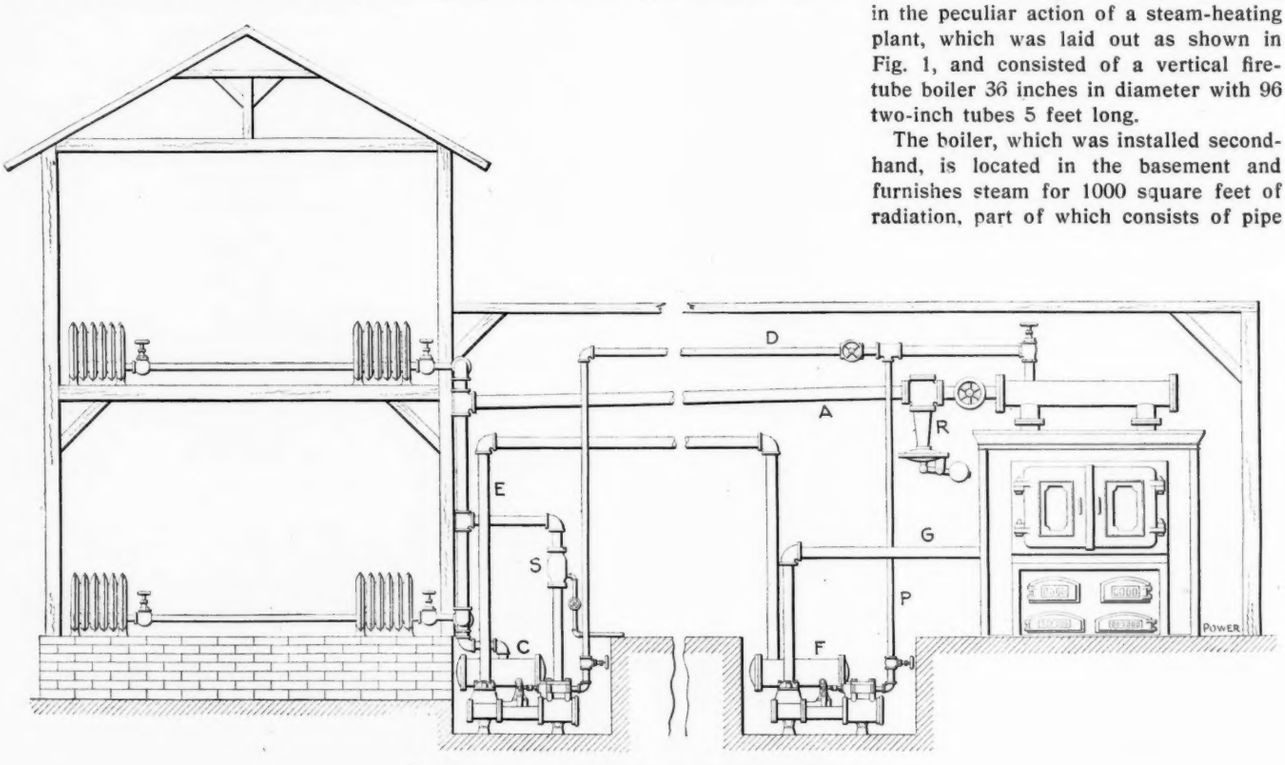
The original part of a certain factory was but one story high, and quite long in order to secure the required floor space. A pair of tubular boilers were installed for power and heating purposes, and an indirect system of heating was in use. The water of condensation from the coils of steam pipes, around which air was circulated by a fan, flowed to the receiver nearest the boilers, and was used as feed water which was handled by a pump standing on the same base.

Later, a two-story addition was built at the end of this factory farthest from the boilers. The indirect-heating system already in use was not sufficient for this extra service, and it was found inexpedient to increase its capacity. There was no cellar under the long building and owing to the nature of the ground it was not advisable to build one. Also, there were several doors in the sides of this building; hence the return pipe could not be carried above the floor, as it would cross the doorways. The following plan was recommended to overcome these objections to the ordinary method of returning hot water by gravity to the receiver provided for this purpose.

Steam from the boilers is delivered to the reducing valve *R* and is reduced to about 5 pounds pressure. The main supply pipe *A* is carried on suitable hangers overhead in the factory where it does not interfere with anything else. Water from this pipe drains into the secondary receiver, leaving dry steam for the radiators on both floors. The water of condensation returns through the single-pipe system and flows by gravity into the receiver *C*.

Steam at boiler pressure is supplied through the small pipe *D* to operate the secondary receiver pump, which exhausts through separator *S* into the heating system. This pump discharges hot water through pipe *E* into the main receiver *F* and it is returned to the boilers through the feed pipe *G*. Steam to operate this pump is delivered through pipe *P* and is exhausted into the heating system through an exhaust pipe, not shown.

This arrangement admits of heating the two-story addition when the main one-story building is not in use, which is a desirable feature in this case. These two pumps and receivers operate automatically in connection with each other, keeping the entire system free from water at all times.



Section through Building Showing Piping

Water Hammer in Heating System

By C. B. Hudson

Some months ago I became interested in the peculiar action of a steam-heating plant, which was laid out as shown in Fig. 1, and consisted of a vertical fire-tube boiler 36 inches in diameter with 96 two-inch tubes 5 feet long.

The boiler, which was installed second-hand, is located in the basement and furnishes steam for 1000 square feet of radiation, part of which consists of pipe coils and the remainder of radiators which are located on two floors.

Connections were made to the boiler as shown in Fig. 1. Steam was taken from the top head through a 1¼-inch pipe and stop valve *A*.

The 1¼-inch pipe led into a tee in the 3-inch main, which supplied steam to all radiators and coils. Connection *B* is a drip for draining the pocket formed in the 1¼-inch pipe.

As the building was not in use more than three times a week, the system was not in constant service. Each time it was put in operation the water would leave the gage glass entirely and would return only when the pressure was lowered to the zero point or near it. At frequent intervals water hammer would develop in the coils.

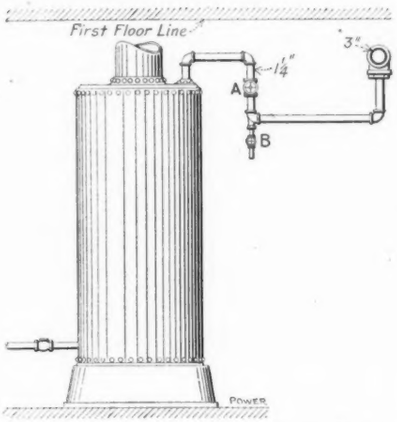


FIG. 1. ORIGINAL CONNECTIONS TO BOILER

Inspired by a desire to know the cause of the trouble, the writer secured permission to look the system over and make the necessary repairs. A brother engineer was called in and a change was made as shown in Fig. 2. A hole was cut in the boiler shell near the top head and a 3-inch "pad" was bolted on and connection was made with the main as shown. The system now works perfectly and the water level remains practically constant.

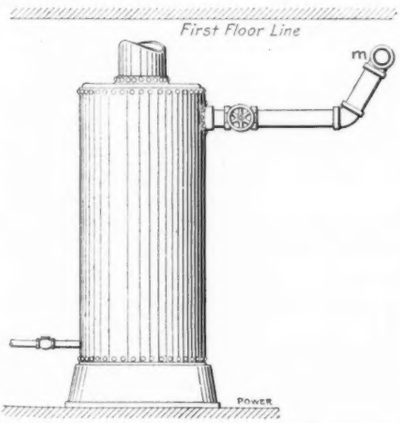


FIG. 2. NEW ARRANGEMENT OF PIPING

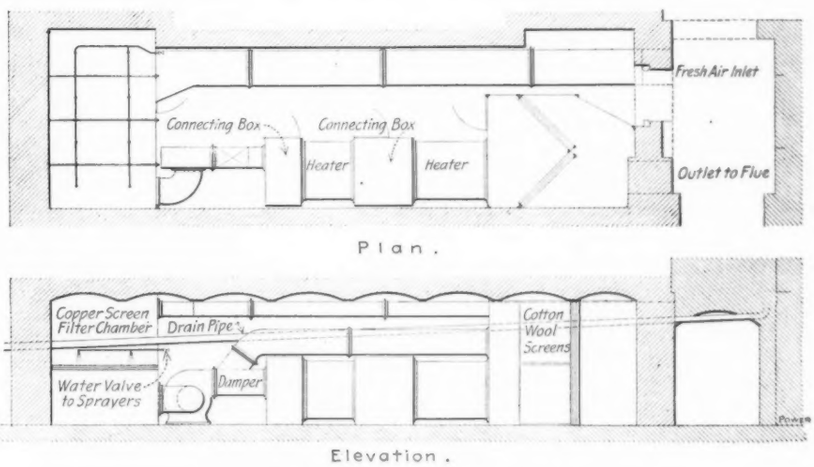
The water hammer was undoubtedly caused by the loop shown in Fig. 1, as the water resulting from condensation in the main would run to the lowest point, and when the pocket was full the water would be blown out into the coils and radiators.

Taking out the pocket, as shown in Fig. 2, stopped the water hammer, and increasing the size of pipe from the boiler to the main equalized the pressure and allowed the condensation to return with a head low enough so that the coils were kept free of water.

LETTERS

Ventilation of Buckingham Palace

To keep the air in a room fairly sweet, say not to contain more than from seven to eight parts of carbon dioxide in 10,000 parts of air, there should be a supply of 3000 cubic feet for each person per hour, according to the British School Board requirements. A room 30 feet square by 15 feet high contains 13,500 cubic feet of air, and to change this 10 times per hour will mean an hourly supply of 135,000 cubic feet. A cubic foot of air increases approximately one grain in weight for every degree fall in temperature. If, therefore, the outside temperature is at 30 degrees and the inside at 60, a cubic foot outside weighs 30 grains more than the same volume inside, and to attempt to ventilate a room by an open window under these circumstances would cause a serious draft, as the air obeys the natural law of gravitation.



GENERAL LAYOUT OF VENTILATING SYSTEM

The illustration represents a ventilating system which was installed in Buckingham palace for the late King Edward VII. Fresh air is drawn in by a motor-driven fan having a 22-inch inlet and a 36-inch runner, rotating at from 230 to 350 revolutions per minute. The air previous to reaching the fan is brought in contact with a spray of water, which washes the particles of soot from it. It then passes through brass screens of 144 meshes to the square inch and is delivered by the fan. The latter forces it through two tubular heaters, either of which may be cut out as the requirements necessitate. A bypass is also available to pass air direct from the fan to the filter chamber if the rooms are too warm.

The air when in the filter chamber is forced through 3 inches of cotton wool, and may be perfumed if required, or pure oxygen may be added from the tanks provided for that purpose. The plant has been designed to enable the connecting boxes and chambers to be cleaned as quickly as possible, as the cotton-wool screens are in use only six hours before they are as black as the proverbial "ace of spades."

A duplicate plant has recently been added, the only difference being a glazed-brick filter chamber to take the place of the sheet-iron one first planned.

H. G. BOYLE.

Cheshire, Eng.

Vapor Pump Troubles

The article by John Watson on page 438 of the issue of September 19, "Potblyn—Pump Doctor," calls to mind a number of experiences I have had with pumps and receivers in connection with low-pressure heating systems. I have been led to believe that the trouble is due to a variation in pressure in the receiver rather than to a variation of the temperature of the water, and I have reasoned it out in this way:

Take a low-pressure heating system working at five pounds pressure. The receiver will be filled with steam above the water level at a pressure anywhere from five pounds down. Then if cold water is admitted into the steam space, the pressure will immediately drop, due to sudden condensation of the steam, down to a point where the water begins to boil, and this reduction of pressure seems to be sufficient to overcome the head of water, and any displacement of the plungers will be filled with vapor instead of water. It is a noticeable fact that when trouble of this kind occurs the water is usually very hot.

I have also had the same thing happen where no makeup water was used, the cause being the irregular return of the condensation due to an improperly drained heating system.

On attaching a low-pressure gage to the receiver, I noticed that whenever one of these slugs of water came, the needle would drop back on the pin, and away would go the pump. I have been able